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Medicinal and biological values of *Callistemon viminalis* extracts: History, current situation and prospects

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ABSTRACT

Callistemon viminalis (*C. viminalis*) is a plant that has been reported to have various medicinal values such as antibacterial, antifungal, antioxidant activities and other pharmaceutical and insecticidal properties. This review covers the potentials, applications and properties of different extracts from different parts (branches, flowers, fruits, bark, leaves) of *C. viminalis*. Furthermore, the chemical structures of the bioactive compounds were reported for biological activities. All the results supported the traditional uses of *C. viminalis* in folk medicine. In addition, some researches supported the use of *C. viminalis* extracts for the preparation of metal oxide nanoparticles.

1. Introduction

Callistemon belongs to family Myrtaceae, consists of 34 species, and is characterized for its cylindrical, brush like flowers resembling traditional bottlebrush. *Callistemon viminalis* (*C. viminalis*) (weeping bottlebrush) is a small tree or shrub native to Australia, and reaching 4 m high in temperate areas where its natural occurs [1–3]. Ecologically, *Callistemon* species as a farm tree are planted for forestry plantations or ornamental purposes [1], and for weed control [4]. In traditional Chinese medicine pills, *C. viminalis* is used for treating hemorrhoids [5,6]. Hot drink locally 'tea' in Jamaica from *C. viminalis* has been used for the treatment of gastro-enteritis, diarrhea and skin infections [7]. *C. viminalis*, native to New South Wales, Australia, is an herb that has been used by natives for a long time to treat gastro-enteritis, diarrhea and skin infections [8].

Dozen phytochemical researches have been carried out on *C. viminalis* extracts, and showed that the plant is rich in phenolics, triterpenoids, flavonoids, saponins, steroids, alkaloids, tannin, carbohydrates, amino acids and proteins compounds [2,9–12].

Perusal of reports related to essential oils (EOs) from leaves included 1,8-cineole (47.9%–82.0%) as the predominant constituent of EO [13–20]. Sesquiterpene lactones showed good activity against *Saccharomyces cerevisiae*, *Bacillus subtilis* (*B. subtilis*), *Staphylococcus aureus* (*S. aureus*), and *Escherichia coli* (*E. coli*) [21]. Terpenoid compounds extracted from *C. viminalis* were characterized by sharp taste, anti-microorganisms, food conserved, analgesic for pain and tonics [21].

Different solvents extraction as well as EOs from *C. viminalis* grown in different regions around the world,

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showed a good antibacterial, antifungal and antioxidant activity [11,16,18–25]. For example, *n*-hexane of leaf extracts showed potential activity against skin pathogen *S. aureus*, *Streptococcus pyogenes* and the enteric *Bacillus cereus*, while less activity was found against than intestinal pathogen (*Shigella sonnei*, *Salmonella enteritidis* and *E. coli*) [24]. Crude water extract (1 mg/mL) reduced biofilm of *Pseudomonas aeruginosa* (*P. aeruginosa*) formation up to 89% [26].

Because extracts of *C. viminalis* are rich in polyphenols and flavonoids content, they have advantages for nanoparticle synthesis which showed good eliminating in the process of maintaining cell cultures [27–29]. The nanoparticles were successfully synthesized using *C. viminalis* leaf extract or flower as reducing agent and stabilizer for nanoparticles. Aqueous (Aq) leaf extract of *C. viminalis* was used to synthesis gold nanotriangles, which was performed in minutes rather than hours, under very mild conditions [30] as well as metal oxide nanoparticles [27]. Therefore, the present review article summarizes the medicinal and biological values of *C. viminalis* extracts.

2. Taxonomy of *C. viminalis*

C. viminalis belongs to kingdom of Plantae, subkingdom of Tracheobionta, superdivision of Spermatophyta, division of Magnoliophyta, class of Magnoliopsida, order of Myrtales. *C. viminalis* is a genus of *Callistemon* in the family of Myrtaceae. Its species include *Metrosideros viminalis* Sol. ex Gaertn., *C. viminalis* (Sol. ex Gaertn.) G. Don, *Melaleuca viminalis* (Sol. ex Gaertn.) Byrnes.

3. Extraction methods

3.1. EOs extraction

Clevenger-type apparatus, a hydro-distillation method, was used to extract the EOs from the different plant parts for 3 h. The obtained oils were dried over anhydrous Na_2SO_4, and stored at 4 °C. GC/MS was used to analyze the chemical compositions of EOs [18,25,31].

3.2. Different solvents extraction

Zubair *et al* [32] diagramed simple method for the extraction of the grinded fine powder of leaves using different solvents with different polarities. Salem *et al*. [33] explained the extraction with methanol (MeOH) from leaves and branches and its successive fractionations in different solvents with ethyl acetate, chloroform and then with *n*-butanol saturated with water and the remaining was Aq fraction. Furthermore, fruits and bark were extracted with MeOH and further fractionated by petroleum ether, CH_2Cl_2 and EtOAc [34]. The plant material could be extracted using hot water, freeze-dried and stored at −20 °C until needed [26]. Other study revealed that the dried ground plant material could be extracted using distilled water in a water bath at 70 °C for 1.5 h to afford the Aq extract [24].

3.3. Extraction with n-hexane

Pulverized leaves could be extracted using *n*-hexane in a Soxhlet apparatus [32].

4. Pharmacological and biological activities

4.1. Antibacterial and antifungal activities

Different extracts of *C. viminalis* including Aq, MeOH and *n*-hexane extracts showed potential activity against some bacterial strains, where the MeOH extract observed good activity against the methicillin-resistant *S. aureus* with inhibition zone value of 25.61 ± 2.11 mm than that the non–methicillin-resistant *S. aureus* (inhibition zone [17.41 ± 1.10] mm) [24]. The extracts' potency is attributed to different chemical compositions of *C. viminalis* [35]. Remarkable antimicrobial activity of the EO was found against *S. aureus*, *Enterobacter cloacae*, and *Streptococcus faecalis*, with minimum inhibitory concentrations (MICs) value of 0.08, 0.63, and 0.63 mg/mL, respectively, while the smallest activity was found against *Serratia marcescena* (MIC 5 mg/mL) and *P. aeruginosa* (MIC 5 mg/mL) [16,18].

Aq extract of *C. viminalis* inhibited nematode death by *P. aeruginosa* strains (PAO1 and PA14) without host toxicity, which suggesting further development as anti-infectives [26]. The extracts dissolved from the inflorescence of *C. viminalis* in water and ethanol extracts have been reported strong antibacterial against *Chromobacterium violaceum* and *Agrobacterium tumefaciens* [23]. Aq extracts of flowers and leaves have been shown an antibacterial activity [16]. Most extracts from the branches did not show measurable activity against the growth of some phytopathogenic potato soft rot bacteria [11].

Good to moderate antimicrobial activity of methanol leaf extract (MEOHLE) was found [25]. The EO, MeOH extracts, and ethyl acetate fraction extracted from the leaves exhibited high significant activity against *B. subtilis*, *B. cereus*, *Micrococcus luteus*, *Sarcina lutea* and *S. aureus*, *E. coli*, *Serratia marcescens*, *Salmonella typhi*, *Proteus vulgaris* and *P. aeruginosa*.

The Aq and alcoholic extracts from leaves have antibacterial activity against *S. aureus*, *Streptococcus Pneumonia*, *Staphylococcus epidermidis*, *Klebsilla pneumonia*, *Klebsiella oxytaci*, *Proteus vulgaricus*, and *E. coli*, however, the watery extract was more potent than ethanol extract against pathogenic bacteria [36].

The EO from leaves of *C. viminalis* showed some antifungal activities against *Botrytis cinerea*, *Fusarium oxysporum*, and *Fusarium solani* [19]. The crude extracts of aerial parts (leaves and flowers) of *C. viminalis* had very high activity against *Candida albicans* and *Candida kefyr*, in addition, to their activities against G^+ ve and G^- ve bacteria [37]. The inhibitory actions of the extracted alkaloids from *C. viminalis* were more effective against *Oscillatoria limnetica*, and *Anabaena cylindrical* increased along with the concentrations revealing a regular pattern [38]. MeOHLE, which confirmed the presence of steroid, terpenoids, flavonoids, tannin and alkaloids was exhibited significant activity against *E. coli*, *S. aureus, Aspergillus niger* and *C. albicans* [39].

The MIC values of *C. viminalis* active extracts against the bacterial strains *Pasturella multocida*, *E. coli*, *B. subtilis*, and *S. aureus* and the fungal strains *Alternaria alternata*, *Ganoderma lucidum*, were ranged from 0.52 to 12.0 mg/mL [40]. Strong antibacterial activity of leaf crude extracts from *C. viminalis* against *B. subtilis* was found (inhibition zone 14.67 mm with MIC 0.312 mg/mL) but not active against the fungi *Aspergillus flavus*, *A. niger*, *Cladosporium oxysporum*, and *Penicillium oxalicum* [41]. The MeOH extract of

C. viminalis bark showed moderate activity against the incubated wood with the *Trichoderma harzianum*, *Alternaria tenuissima* and *Fusarium culmorum* [42,43]. Antibacterial activity from leaves, flower, stem with bark MeOH, ethyl acetate, *n*-hexane and distilled water extracts against *B. subtilis* were 13.0 mm, 8.0 mm, 11.0 mm, 0 mm; 15.5 mm, 13.0 mm, 12.5 mm, 13.5 mm; and 8.5 mm, 0 mm, 0 mm, 7 mm, respectively, and all the extracts did not show activity against *E. coli* [44].

Other antibacterial activity was assayed in the manner of Anti-quorum sensing activity (QS). The Aq and ethanol extracts (inflorescences part) and the Aq extract (leaves) have strong anti-QS activity [23]. The Aq extracts caused a significant inhibition of LasA protease, LasB elastase, pyoverdine production, and biofilm formation and caused the inhibition of QS genes and QS-controlled factors, with marginal effects on *P. aeruginosa* and *Agrobacterium tumefaciens* growth [23,45].

4.2. Haemolytic activity

The haemolytic activity of *C. viminalis* extracts against human blood erythrocytes (RBCs) was studied and the lysis percentage of RBCs was found to be in the range of 1.95%–6.33%, which could be a potential source of therapeutic drugs [40]. The haemolytic effect of Leaves' MeOH extract was found in the range of 1.79%–4.95% [32]. The order of % haemolysis of various extracts were chloroform > ethylacetate > 90% MeOH > 95% MeOH > absolute MeOH > petroleum ether > *n*-butanol. The effects of *C. viminalis* leaves alcoholic extract on renal profile test for infected rabbits with *Streptococcus pneumonia* were found to be significant variation in level of blood urea nitrogen, creatinine, creatinine kinase and uric acid [36].

4.3. Anthelmintic activity

In vitro the EOs of *C. viminalis* showed good Anthelmintic activity, which produced greater efficacy against earthworms (*Pheretima posthuma*) and tapeworms (*Taenia solium* Linn.) than piperazine phosphate, additionally, the activity against hookworms (*Bunostomum trignocephalum*) was comparable to that of hexylresorcinol [46–48].

4.4. Insecticidal activity

The EO of *C. viminalis* showed moderate activity in killing of the stored-grain insects namely, *Sitophilus oryzae*, *Tribolium castaneum* and *Rhyzopertha dominica* [49]. The isolated compound viminadione A from the aerial parts exhibited moderate insecticidal activity against *Musca domestica*, *Aphis fabae* and *Thrips tabaci* compared to pyrethrum extract, while viminadione B was less active [50,51].

The highest concentrations of EO from dried leaves applied on grains (0.40 μL/g) and on filter paper discs (0.251 μL/cm^2) caused 72.6% and 80% mortality rates, respectively, against *Acanthoscelides obtectus*, a major *Phaseolus vulgaris* pest of stored beans in Cameroon, while both powder and acetonic extract showed no activity against the insects at the tested concentration [52]. Furthermore, EO showed activity against adults of *Acanthoscelides obtectus* and *Callosobruchus maculatus* [31].

C. viminalis leaf extracts observed a potential larvicide activity, where the isopropanol extract was highly effective against *Aedes albopictus* larvae with LC_{50} value of 71.34 ppm [53]. In addition, slightly attractancy at 50 ppm with almost 2-fold egg lying in treated bowls was found. Fruits, bark and leaf MeOH extracts showed values of LC_{50} of 6.2 ppm, 32 ppm and 40 ppm, respectively, against the vector of schistosomiasis, *Biomphalaria alexandrina* snails. The site of action reported from the extracts against insects found by histopathological studies was localized gland [54]. The MeOH extracts showed schistosomicidal activity ($LC_{50} \leq 15$ μg/mL) [55]. Leaf and twigs EO of *C. viminalis* demonstrated strong acaricidal and repellent activities on two-spotted spider mites in both dipping and choice tests with mortality of 71.2% ± 16.3% against *Tetranychus urticae* female adults [56]. The fumigant oil with LC_{10}, LC_{30} and LC_{50} values were 8.42, 15.86 and 24.60 μL/L air against *Ephestia kuehniella* larvae and the topical LD values were 4.28, 9.64 and 16.91 μg/insect. In addition, the oil caused a drastic reduction in total hemocyte count of treated larvae in a dose-dependent manner at all time intervals [57].

5. Phytochemical screening of *C. viminalis* and antioxidant activities

From the literature, screening of phytochemicals from *C. viminalis* leaf extracts showed the presence of glycosides flavonoids, alkaloids, proteins, carbohydrate, saponins, tannin, and phenols, where these compounds have been reported to own potential biological activities [2,11–13,58,59]. The presence of these chemical groups refers to the bioactivity of the extracts from *C. viminalis*, also these groups have been previously shown good antibacterial, antifungal, and antioxidant activities. *C. viminalis* oil exhibited strong 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity, with IC_{50} values of 72.98 μg/mL [20].

The total phenolic contents in MeOH extract and ethyl acetate (EtOAc), butanol (*n*-BuOH), and Aq fractions were 44.30 ± 3.78, 69.10 ± 3.50, 14.32 ± 2.32 and 17.21 ± 1.13 mg GAE/g extract, respectively. The total flavonoid contents were 45.36 ± 2.03, 28.55 ± 2.06, 10.12 ± 1.33 and 18.34 ± 1.36 mg CE/g extract with MeOH extract and EtOAc, *n*-BuOH, and Aq fractions, respectively. The total antioxidant activity (TAA%) was ranged between 8.70% ± 1.15% (Aq fraction) and 88.60% ± 1.51% (EO) [33].

The ferric reducing ability of plasma (FRAP) power was almost same as ascorbic acid [60,61]. The reducing capacity of a compound Fe^{+3}/ferricyanide complex to the ferrous form may serve as indicator of its antioxidant capacity [62,63]. Among some extracts (MeOH extract and EtOAc, chloroform and Aq fractions), leaves EO exhibited the highest TAA% (88.60% ± 1.51%) comparable to Gallic acid as a standard compound (80.00% ± 2.12%) [33].

The TAA% of the crude extract, petroleum ether, CH_2Cl_2 and EtOAc fractions together with the compounds 6, 7, 9, 10, 11, 12 and 13 presented in Table 1 [34] showed good antioxidant activities compared to ascorbic acid. MeOHLE contained appreciable levels of total phenolic contents ([0.27–0.85] GAE mg/g) and total flavonoid contents ([2.25–7.96] CE mg/g), and the IC_{50} ([28.4–56.2] μg/mL) and % inhibition of linoleic acid peroxidation (40.1%–70.2%) was reported [37]. The correlation between different antioxidant assays and oxidation parameters observed from EO observed that MeOHLE was more potent regarding to enhance the

Table 1
Chemical constituents of extracts and essential oils from *C. viminalis*.

Part	Main chemical components	Extract type	Action	References
Leaves	1,8-Cineole (64.53%), α-Pinene (9.69%), α-Terpineol (7.90%)	EO	Antibacterial activity	[11]
Leaves	1,8-Cineole (61%), α-Pinene (24%), and menthyl acetate (5.3%)	EO	Antibacterial activity	[17,19]
Leaves	1,8-Cineole (71.77%), α-Pinene (11.47%), Terpinen-4-ol (3.185)	EO	Antibacterial and antifungal activities	[20]
Leaves	1,8-Cineole (65.92%), α-Pinene (12.34%)	EO	Antioxidant, antiviral activities	[21]
Leaves, flowers	1,8-Cineole, α-Pinene and α-Terpineol were found in concentrations of 50.4%, 25.8% and 8.7% in the EOs obtained from the leaves and 48.8%, 24.5% and 3.9% in the EOs obtained from the flowers	EO	Antitumoral activity	[64]
Red flower	Pelargonidin-3,5-diglucoside, Cyanidin-3,5-diglucoside, Kaempferol, β-pinene, 1,8-cineol; Pyrogallol; Catechol, Betulinic acid, α-amyrin, Oleanolic acid, *β*-sitosterol	Aqueous extract	Synthesis of nanoparticles	[31]
Shade dried leaves	2,5,5,6,8a-Pentamethyl-trans-4a,5,6,7,8,8a-hexahydrogamma-chromene (27.60%), (10E,12E)-10,12-tetradecadienyl acetate (11.62%), Z-7-tetradecenal (4.98%), 1,3-cyclohexadiene (3.97%)	*n*-Hexane	Antioxidant activity	[32]
Fruits and bark	3,4-Dihydro-2-(hydroxymethyl)-4-methyl-2H-pyrrol-2-ol (5) with the known compounds lupeol (1), octacosanol (2), β-sitosterol (3), betulin (4), betulinic acid (6), ursolic acid (7), corosolic acid (8), β-sitosterol-3-O-β-D-glucoside (9), methyl gallate (10), gallic acid (11), catechin (12), ellagic acid (13) and 3-O-acetylursolic acid (14) (compound 14 isolated from bark and not detected in fruits) (Figure 2)	Total extracts, petroleum ether (1–4), CH_2Cl_2 (5–9) and EtOAc (10–13) fractions	Antioxidant activity	[35]
Aerial parts	Tetramethylcyclohexenedione, viminadione A and viminadione B		Insecticidal activity	[51]
Aerial parts	(i) Gallic acid, (ii) Me gallate, (iii) quercetin 3-O-*β*-L-arabinofuranoside (avicularin), (iv) quercetin 3-*O*-α-D-galacto-pyranoside (hyperin), (v) quercetin 3-*O*-α-L-rhamnopyranoside (quercitrin), (vi) quercetin 3-O-β-D-glucuronopyranoside, (vii) quercetin, (viii) 1-O-galloyl-β-D-glucopyranose (glucogallin), and (ix) 2,3,5-(S)-flavogallonoyl-4,6-(S)-hexahydroxydiphenoyl-D-glucopyranose (castalagin)	Aqueous methanol extract	Hepatoprotective activity	[65]
Leaves	3-O-α-L-Arabinopyranoside hederagenin, Hederagenin 3-O-β-glucopyranosyl-(1→2)-β-D-xylopyranoside	*n*-Hexane, ethyl acetate, n-butanol	Antibacterial, antifungal, antioxidant activities	[66]
Leaves	3-Hydroxy-20(29)-lupen-28-oic acid (betulinic acid)	Ethyl acetate	High antisickling activity	[66]
Fruits	(±)-Calliviminones A and B, two Diels–Alder adducts of polymethylated phloroglucinol and myrcene with unprecedented spiro-[5.5] undecene skeleton			[67]
Fruits	Calliviminones CH (1–6), six novel Diels–Alder adducts of a polymethylated phloroglucinol derivative and acyclic monoterpene (myrcene) (Figure 3)	Nitric oxide production in lipopolysaccharide-induced		[68]

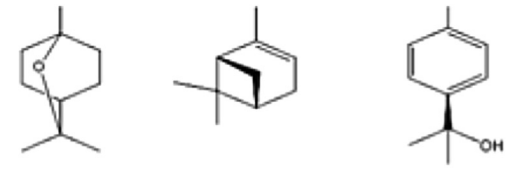
oxidative stability of sunflower oil [32]. In addition, the IC_{50} of DPPH radical scavenging was 28.4–56.2 μg/mL [32].

Aq MeOH extract (Aq-MeOH) of aerial parts showed a significant reduction in elevated alanine aminotransferase, aspartate aminotransferase and alkaline phosphatase serum enzyme levels as compared with paracetamol group. In addition, the Aq-MeOH extracts showed a significant scavenging activity using the DPPH method [69].

6. Nanoparticles synthesis using extracts of *C. viminalis*

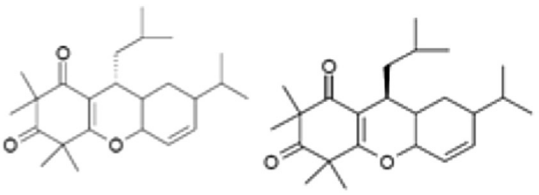
Plant extracts provide advancement over chemical and physical method as it is environmentally benevolent, simple, inexpensive, easily scaled up for large-scale synthesis and further there is no need to use high pressure, energy, temperature and toxic chemicals [30,65,70]. A green method for the synthesis of stable gold nanoparticles (Au NPs) has been done under very mild conditions using Aq leaf extract (AqLE) of *C. viminalis* [30] with a triangular gold nanoparticles form, and does not require any of the conventional stabilizing ligands.

For the first time, gold nanoparticles and Sm_2O_3 nano-scaled particles prepared with AqLE and red flowers extract from *C. viminalis*, respectively, were well characterized by X-ray Diffraction (XRD), Transmission electron microscopy (TEM), quasi-elastic light scattering, Ultraviolet (UV)–visible spectroscopy, Raman and X-rays photoelectron spectroscopy techniques [30,71]. The antimicrobial potential of plant protein-coated HgO nanoparticles still prevailed as it was present in the pure uncoated bulk HgO, however, the crude extract did not

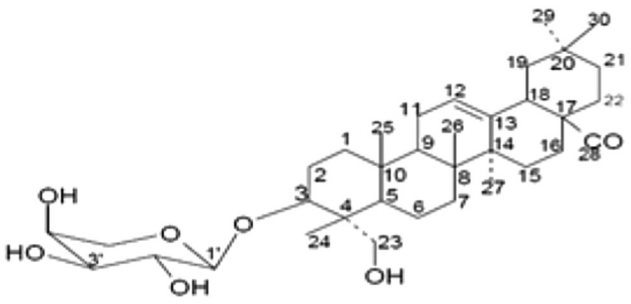


1,8-Cineole α-Pinene α-Terpinen

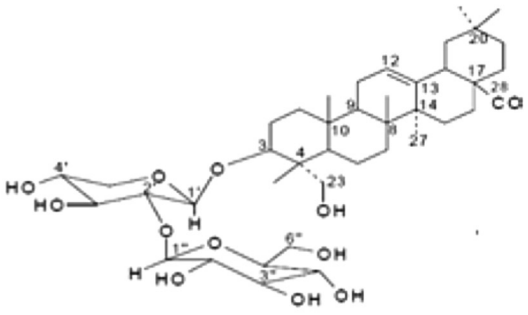
Most essential oil composition[13-21]



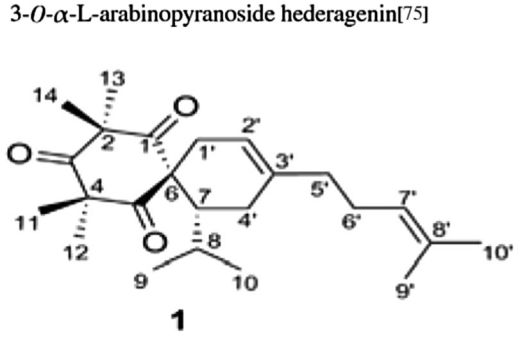
Viminadione A[55] Viminadione B[51]



3-*O*-α-L-arabinopyranoside hederagenin[75]



Hederagenin3-*O*-β- glucopyranosyl -(1→2)- β-D-xylopyranoside[75]



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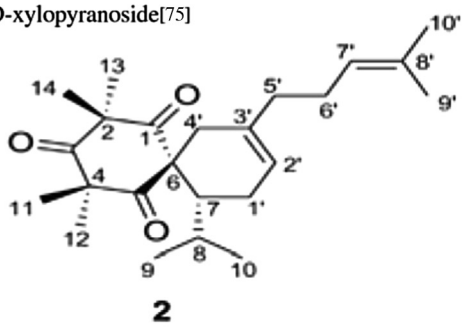
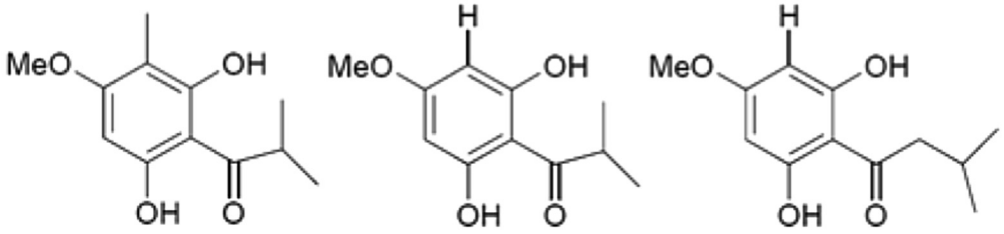
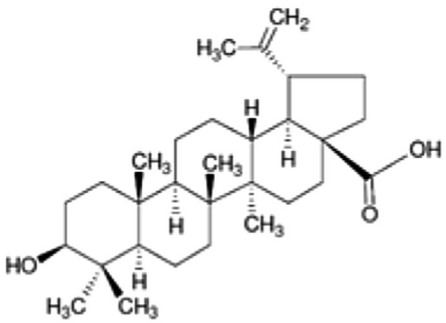


2

Structures of (±)-Calliviminones A (1) and B (2)[67]



Phloroglucinols isolated from *C. viminalis*[73]



Betulic acid[66]

Figure 1. Some of the isolated and identified chemical composition from extracts of *C. viminalis* [73].

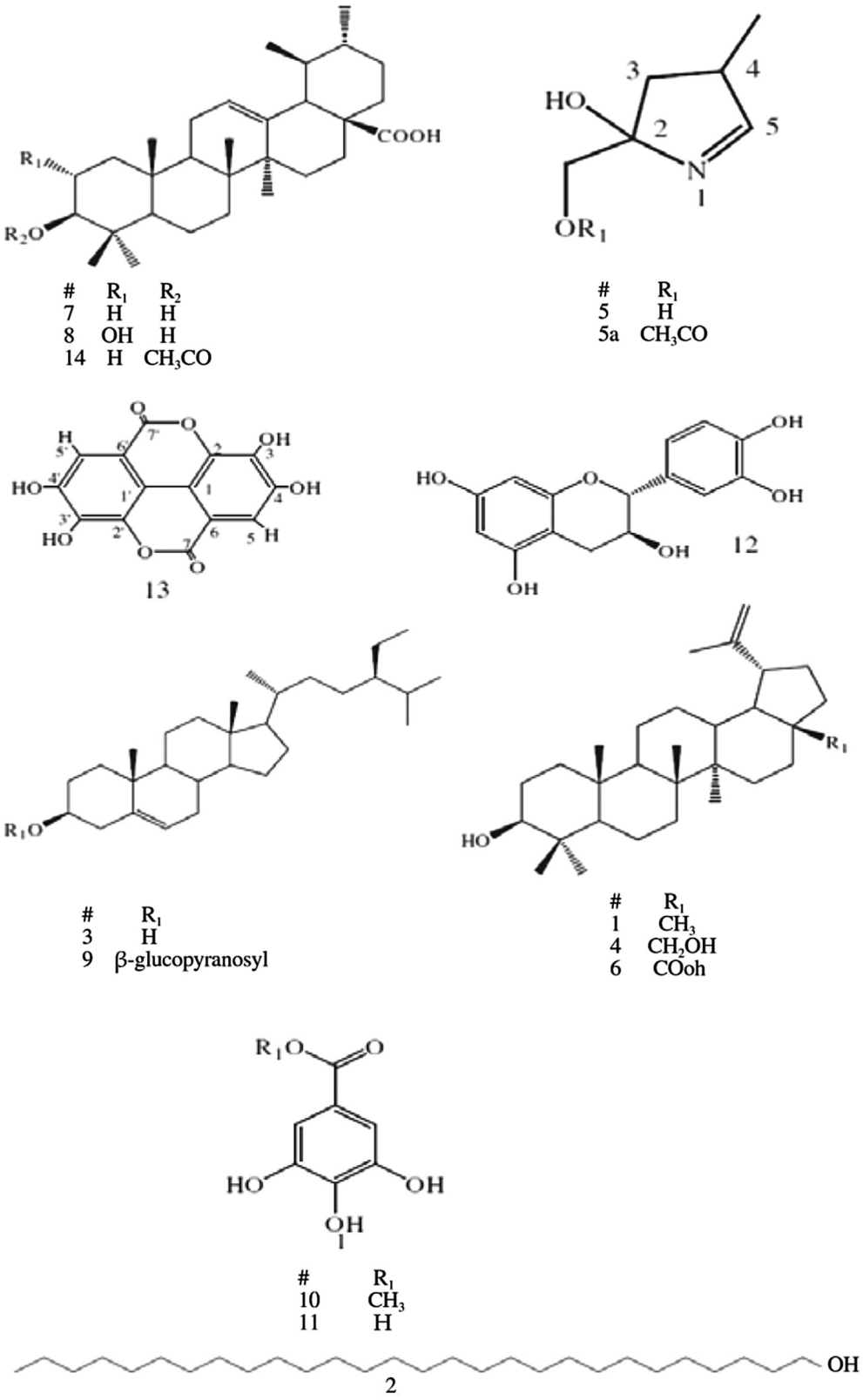


Figure 2. Structure of the isolated compounds (1–14) from fruits [34].

show any antibacterial activity. The AqLE of *C. viminalis*, used for the synthesis of silver nanoparticles, inhibited the growth of *E. coli*, *S. aureus*, *Klebsiella pneumoniae* and *Salmonella typhimurium* [29]. Recent study showed that red dye extracts obtained from *Callistemon* red flowers, which are rich in flavonoids, saponins, steroids, alkaloids and triterpenoids were used for single-phase α-Cr_2O_3 nanoparticles' green synthesis [72].

7. Other biological activities

The EO showed good antiviral activity with TC_{50} (50% cytotoxic concentration) value 676.35 μg/mL with significant lower toxicities towards the RC-37 cells with C_{50} (inhibitory concentration for 50% of plaques) for Herpes simplex virus 1 (HSV-1) (63.73 μg/mL) and selectivity index (=TC_{50}/IC_{50}) was 10.61 [20]. With the antitumoral activity, the cytotoxic

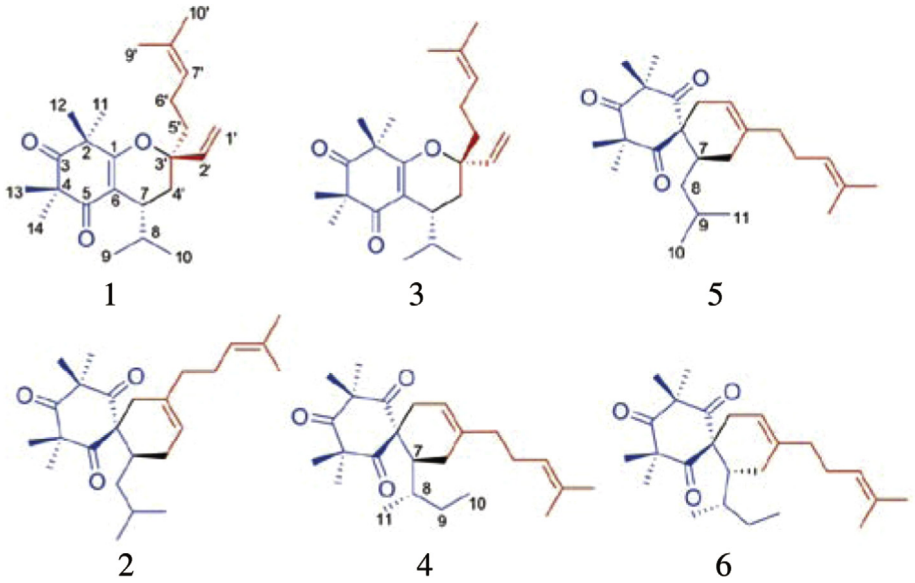


Figure 3. Calliviminones C–H: six new hetero- and carbon-Diels–Alder adducts with unusual skeletons from the fruits of *C. viminalis* [67].

activity of the EO was observed only in melanoma cultures (HT144), where the cultures treated for 48 h with EO (leaves and flowers) at 200 μg/mL reduced the viability by 40% and 25%, respectively. Thus, the antiproliferative activity of the EO (leaves) was more pronounced than the EO (flowers) in cells derived from melanoma [74].

8. Chemical composition of extracts and their biological activities

Literature from different regions around the world showed that the plant has many different chemical compositions in their different parts (leaves, flower, fruits, wood, bark). Some of the isolated compounds from different parts of the plant and obtained from different extracts are presented in Table 1.

Most of the studies were focused on the EO composition of *C. viminalis* and it was shown that there were differences in the quantities of the main compound of the oil even in the same country. The leaf EO of *C. viminalis* from Egypt showed the presence of 1,8-cineole (eucalyptol) as the main compound with 47.9% [15], 64.53%, 71.77% [19] and 65.92% [20]. In the South Africa, it was 83.2% [18]. In addition, linalool, limonene, terpinen-4-ol, α-terpineol, α-pinene, and menthyl acetate were also reported [18–20].

Furthermore, it was reported that the compounds 1,8-cineole, α-pinene and α-terpineol were found in concentrations of 50.4%, 25.8% and 8.7% in leaves EOs and 48.8%, 24.5% and 3.9% in flowers EOs, respectively [74].

Figure 1 showed some of the isolated compounds as raised in the literature. The isolated phloroglucinols from *C. viminalis*, which have been observed good antibacterial activity against *E. coli* and *B. subtilis* also, have antiviral and antioxidant activities [66,75] (Figures 2 and 3).

9. Concluding remarks and research needs

From the above survey about the biological effects of extracts from different parts of *C. viminalis*, it can be concluded that the EOs and extracts as well as the isolated compounds have a potent biological activity (antibacterial, antifungal, antiviral, haemolytic, anthelmintic, and insecticidal activities) and a good media for nanoparticle synthesis. The research needs to use these extracts in commercial scale in the production of pharmaceutical purposes.

Conflict of interest statement

We declare that we have no conflict of interest.

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