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Chemical Composition And Biological Activity Of Extracts *From Conyza* Species

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Abstract
The genus Conyza (Asteraceae) comprises about 50 species and found in the tropical and warm regions. Extracts from Conyza species have numerous pharmacological applications. The aim of this study was review the chemical composition and biological activity of Conyza species. Extracts from the plants have antimicrobial, antioxidant, cytotoxic, anti-inflammatory, antiplasmodial, analgesic, antiviral, allelopathic and insecticidal activities. The constituents of essential oils from Conyza species include limonene and β-farnesene, were caryophyllene, spathulenol, β-ocimene, lachnophyllum ester, matricaria ester, germacrene D, α-bergamotene, caryophyllene oxide, pinene, bicyclogermacrene, curcumene, cadinene , sesquiphellandrene, camphene, 2,6,7,7a-tetrahydro-1,5-dimethyl-1H-indene-3-carboxaldehyde, 2-heptylacetate, allo-aromadendrene, bisabolene oxide, carvacrol, cis-sabinol, epi-*bicyclosesquiphellandrene, humulene, isoeugenol, isospathulenol, mentha-1,3,8-triene, myrcene, neophytadiene, perillaldehyde, phytol, pinocarveol, pulegone, Sabinene, terpinolene, zingiberene and β-copaen-4-α-ol. The findings indicate that only a few species have been studied including C. bonariencis, C. canadensis, C. sumatrensis and C. floribunda. Further investigations especially on the neglected species is necessary.*

Keywords*: Conyza species; Bioloactivity; Chemical composition; Essential oils*

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I. Introduction

For thousands of years, people have used medicinal plants as health treatments. A large proportion of the African population's primary healthcare requirements are still mostly met by traditional medicine. Previous studies have demonstrated the potential of plant extracts disease management[1-10]. There is evidence that several secondary metabolites produced by plants are effective against diseases causing microbes[11-15]. Despite the availability of effective synthetic pharmaceuticals, research for novel bioactive chemicals is necessary because the majority of the current crop of medications have limitations in terms of side effects and drug resistance[16-22]. Many researchers have concentrated on confirming the effectiveness of medicinal plant extracts through in-vivo and in-vitro trials in recent years[23-25]. Use of herbal medicine is favoured as they are more affordable, easily accessible and chanced of development of resistance by microorganisms is limited[26,27]. Important bioactive compounds including terpenoids, alkaloids, steroids, flavonoids, and quinones have been identified as a result of such investigations[28-32]. The aim of this paper was to review the biological activities and chemical composition of essential oils from *Conyza* species.

II. Bioactivity of Conyza Species

Genus Conyza (Asteraceae) comprises about 50 species, which are found in the tropical and warm regions. Conyza plants' extracts are traditionally used for in a wide range of pharmacological applications (Table 1.), including treatment of malaria, smallpox, chickenpox, sore throat, ringworm and other skin related diseases, toothache and wounds[33-35]. Extracts from some Conyza species have been subjected to in vitro and in-vivo bioassays which have revealed a wide range of bioactivities (Table 1) such as antibacterial, antioxidant, cytotoxic, anti-inflammatory, analgesic, antiviral, antiproliferative, antischistosomal, antiprotozoal, antidiarrheic and insecticidal activities[36-42]. Previous studies have confirmed that Conyza plants are rich in secondary metabolites belonging to different phytochemical groups including alkaloids, terpenoids, steroids, phenolic compound, flavonoids and tannins [43-47]. The chemical profile and bioactivities of extracts from the plants vary depending on the species, habitat, meteorological conditions, seasonal variations, degree of ripeness, geographic locations, and postharvest treatment[48-49].

A number of Conyza species have been investigated for antimicrobial activity against different types of microbes[34,59]. Conyza bonariensis extracts exhibited antimicrobial activity against pathogenic microbes

including Escherichia coli, Staphylococcus aureus, Streptococcus pyogenes, Salmonella typhimurium, Salmonella typhi, Cryptococcus neoformans, Shigella dysenteriae, and Pseudomonas aeruginosa[59,62,63,65,82]. Conyza bonariesis showed antifungal activity against pathogenic fungi causing superficial infection namely including Candida albicans, Malassezia globosa, and Malassezia furfur[63,65,82]. In another study, alcoholic maceration of dry leaves of C. bonariensis exhibited antimicrobial activity against Malassezia sympodialis, Malassezia furfur, Malassezia globosa, C. albicans, C. parapsilosis, Trichophyton rubrum, Trichophyton mentagrophytes, Microsporum canis and Staphylococcus aureus isolated from patients with superficial lesions[60].Conyza Canadensis extracts showed antimicrobial activity against Acinetobacter sp., Acinetobacter baumanni, Bacillus cereus, B. subtilis, Corynebacterium striatum, Corynebacterium sp, Enterococcus faecalis, Escherichia coli, K. pneumonia, Listeria monocytogenes, Pseudomonas aeruginosa, Salmonella typhimurium, Staphylococcus epidermidis, Staphylococcus aureus, Streptococcus pyogenes, S. flexneri, Candida albicans, C. glabarata, Candida kefyr, C. parapsilosis, C. kreusei, C. tropicalis, Cryptococcus neoformans, Trichophyton interdigitalis, Trichophytom longifusus, Rhodotorula glutinis, Aspergillus fumigatus and A. niger[68,70,71,90,91]. Conyza floribunda extracts have showed antimicrobial activity against various bacterial and fungal strains[51,81,82,85,92,93]. Conyza floribunda grown in Kenya exhibited antimicrobial activity against Candida albicans, Trichophyton mentagrophytes and Microsporum gypsium [37]. Bioassay guided research revealed that (24S)- ethylcholesta-5, 22E, 25-trienene 3-O-glucopyranoside, cyasterone, 3-oxofriedooleanane and betulinic acid as the bioactive compounds from the plant[44]. Conyza sumatrensis extracts showed antimicrobial activity against various microorganisms including Staphylococcus aureus, Escherichia coli, Bacillus subtilis, Pseudomona aeruginosa, Salmonella typhi, Klebsiellae pneumonae, Candida albicans, Aspergillus niger, penicillium notatum and Rhizopus stolonifer[40,87,94]. Conyza linifolia essential oil showed antibacterial activity against B. subtilis[86]. Conyza aegyptiaca extracts showed antibacterial activity against two sensitives bacteria Shigella flexneri and Escherichia coli and one resistant Staphylococcus aureus[55].

Table 1: Ethno-medicinal applications and bioactivities of some *Conyza* species

Species	Uses to treat:	Bioactivity	Ref
C. aegyptiaca	Diabetes, female sterility, obesity, cardiovascular diseases and malarial	Antimicrobial, anti-hepatic, anti-hyperglycemic, anti-inflammatory, analgesic, antiviral, cytotoxic, antioxidant, antihemolytic.	50-55
C. blinii	Inflammations and cancers	Anticancer, ulcerogenic	56-58
C. bonariensis	Fever, malaria, coughs, asthma, dyspepsia, diarrhea, rheumatism, gout, nephritis, sore throat, ringworm, chicken pox, bleeding from injuries, headache, toothache and constipation. induce uterine contraction, abortion and stimulate lactation	Antioxidant, antibacterial, antifungal, hepatoprotective, analgesic, anti-inflammatory, anti-amnesic, ulcerogenic, anticoagulant, Insecticidal, nematicidal, phytotoxic.	36,38,41,46,49-66
C. canadensis	Gastrointestinal symptoms, diarrhea, dysentery, sores, pumps, coughs, colds, bronchitis, cystitis and arthritis and diuretic agent	Cytotoxic, antifungal, antibacterial, antiviral, anti-inflammatory, ntiplasmodial, antioxidant, antiagregant, insecticidal, allelopathic, anxiolytic and antidepressant.	67-74
C. dioscoridis	Rheumatic pains, epilepsy, colic, ulcer and cold	Anti-diarrheal, diuretic, antihyperglycemic, antioxidant, antiulerogenic, antimicrobial, anti-inflammatory, antinociceptive, larvicidal, antipyretic, antidiabetic, cytotoxic, molluscicidal, anti-inflammatory, antinociceptive.	45,75-77
C. filaginoides	Stomach upset, diabetes, painful digestive disorders such as dyspepsia, hepatic and biliary colic	Anti-protozoa, antidiarrheal, analgesic, anti-inflammatory	78-80
C. floribunda	Malaria, angina, female, infertility, acquired immunodefiency syndrome (AIDS), dental pain, headache, skin disorders, gastrointestinal tract infections	Antimicrobial, antidiabetic, antioxidant, antiproliferative, analgesic, anti-inflammatory, cytotoxic, immunomodulatory and antiplasmodial.	35,37,54,81-85
C. linifolia	Fever, inflammation, rheumatism, dyspepsia, diarrhea.	Antimicrobial and insecticidal.	86
C. sumatrensis	Fever, inflammation, rheumatism, dyspepsia, diarrhea, chickenpox, smallpox, sore throat, ringworm paralysis, epilepsy and convulsion, asthma, burns, tumors, diarrhea, fever, gastric distress, deworming, whitlow, leprosy, dermatoses, scabies, mycoses, snake bite, microfilaria.	Antimicrobial, antioxidant, antiplasmodial, insecticidal	40,47,49,87
C. triloba	Fever, inflammation,	Anticancer and antioxidant	88,89

Antioxidant drugs defend cells against oxidative damage caused by free radicals. Oxidative cell damage can lead to emergence of illnesses such as cancer and cardiovascular diseases. Conyza species have been investigated for antioxidant activity in previous studies[41,68,74]. Extracts from C. bonariensis showed antioxidant activities in DPPH, ferric and tripyridyltriazine complex models[41,45,59, 67,71]. Conyza Canadensis extracts showed antioxidant and antioxidant activities which were attributed to conyzanol[67,73,74,95]. Erigeron floribundus essential oil exhibited strong antioxidant potential in different antioxidant assays including DPPH free radical scavenging activity, ABTS radical cation scavenging activity, and ferric reducing antioxidant power[83,85]. Ethyl acetate and methanol extracts of C. dioscoridis exhibited significant antioxidant activity with all tested concentrations[77]. Conyza sumatrensis extracts exhibited antioxidant activity, indicating its potential as a source of natural antioxidants. Methanolic extract exhibited significant radical scavenging property with IC_{50} of 17.08 µg/mL [40]. Extracts from C. aegyptiaca exhibited antioxidant activity[54,96]. Conyza trioba[88] and Conyza *japonica* [97] also showed antioxidant activity. The antioxidant activity of Conyza species are attributed to the presence of phenolic and flavonoid compounds in the plants[83].

Conyza species have been used to manage inflammation-related ailments and studies have reported anti-inflammatory activity in some Conyza species[51]. A study investigated the anti-inflammatory activity of Conyza bonariensis extracts using different assays and found that they inhibited the production of various pro-inflammatory cytokines and enzymes, such as TNF-α, IL-6, and COX-2, in human cells[61,98]. Conyza canadensis extracts showed anti-inflammatory activity in vitro and in vivoI[74,99]. Methanol extract of Conyza floribunda inhibited the production of nitric oxide and several pro-inflammatory cytokines, suggesting that it has potential as an anti-inflammatory agent[51,100,101]. In another study, the essential oil of Conyza floribunda exhibited significant anti-inflammatory activity in a rat paw edema model. The anti-inflammatory effect was attributed to the presence of camphor, α-pinene, and limonene in the essential oil[102,103]. In another, a flavonoid glycoside isolated from Conyza floribunda inhibited production of pro-inflammatory cytokines in vitro[100,101]. The anti-inflammatory property of Conyza filaginoides was also reported[80].

Conyza Canadensis extracts exhibited cytotoxic activity against several cancer cell lines, including breast, colon, lung cancer cells, neoplastic cell lines K562 (leukemia), MKN-45 human gastric cancer cells and NCI-ADR / RES (ovary with multidrug resistance phenotype). The anticancer compound from the plant was identified to 3-β-erythrodiol[72,74]. Essential oil of Conyza bonariensis showed cytotoxicity activity against HeLa (cervix carcinoma), A-459 (lung carcinoma) and MCF-7 (breast adenocarcinoma) human cell lines and normal Vero cells (African green monkey kidney)[104]. Conyza sumatrensis extracts and sub-fractions showed cytotoxic activity against breast (MCF-7) and lung cancer (NCI-H460) cell lines. Bioassay guided fractionation of the active extracts led to the siolation of the cytotoxic compounds which were identified as stigmast-5,22-dien-3-O-β-D-glucopyranoside and 2, 3-dihydroxylpropyl hexacosanoate[105]. Conyza triloba extracts inhibited the growth of hepatic mouse Hepa1C1C7, and human colon HT29, breast MCF7, lung A549, prostate PC3 and H4IIE1 cell lines cell lines[88,89]. The bioactive compounds were identified to be euparin, centipedic acid, tarapacol, 15-hydroxy-eudesm-4,11(13)- diene-12-oic acid, pyromeconic acid, and 5- methylcoumarin-4-O-β-D-glucoside and 6-hydroxytremetone[89]. Conyza *japonica* showed cytotoxic activity against human hepatoma cell line (HepG2) and human breast adenocarcinoma cell line (MCF-7)[97]. In other studies, extracts from *Conyza blinii* [57,58,106]. The essential oil Erigeron floribundus exhibited strong cytotoxicity on HCT 116 colon carcinoma cells with an IC_{50} value of 14.89 µg/mL[83].

Conyza species are uses to manage pain in tradition medicine[51,107]. Extracts from some of the species have been tested in different models to determine the pain killing effect. Conyza Canadensis leaf extracts exhibited significant analgesic activity in mice. The extracts showed a dose-dependent reduction in pain sensation in the acetic acid-induced writhing and hot plate tests[73,108,109,110]. Conyza floribunda extracts showed analgesic activity in vivo. The extracts reduced pain sensation in the acetic acid-induced writhing test and the formalin-induced paw licking test in mice[35,51]. Extracts from Conyza bonariensis exhibited a significant reduction in pain sensation in the acetic acid-induced writhing test and the formalin-induced paw licking test[61]. Conyza triloba extracts exhibited analgesic activity in mice[88,89]. In another study, Conyza filaginoides extracts showed analgesic effects[80].

Plasmodium falciparum is the species responsible for the majority of malaria deaths globally. Extracts from Conyza sumatrensis were found to be active against P. falciparum (NF54) and P. berghei (K173) in vitro and in vivo. Bioactivity-guided isolation of n-hexane fraction yielded three compounds with IC_{50} of 34, 17.9 and 18µg/ml, respectively[111,112]. The antimalarial activity was attributed to the presence of flavonoids and terpenoids in the plant. In a study, Conyza floribunda showed significant antimalarial activity against Plasmodium berghei in mice. The extract also had moderate to high cytotoxicity against brine shrimp larvae and Vero cell[84] . In other studies, Conyza albida, Conyza podocephala and Conyza scabrida showed antiplasmodial activity[113,114].

Plant extracts are traditionally to treat wounds. The extracts acts by increasing the rate of wound contraction, enhancing the formation of granulation tissue, and improving the tensile strength of the healed tissue[115]. Conyza species is widely used to manage wounds[74]. However scientific data on would healing

properties of the plant is scanty. Conyza Canadensis extracts stimulated the fibroblast and keratinocyte proliferation. In ethanolic, extract fibroblast division increased 1.6 times at 31.25 µg/mL while in ethyl acetate extract keratinocyte proliferation increased 1.7 times at 10 µg/mL relative to the control[116].

Insects act as pests and vector for diseases. Plants provide an alternative to synthetic insecticides, some of which have been proved to have adverse effect to non-targeted organisms and the environment. Some Conyza species are traditionally used to control insects and pests[107]. In a study, C. bonariensis extracts exhibited insecticidal activity against cowpea weevil Callosobruchus maculatus which is one of the most cosmopolitan pests of stored beans[64]. The extracts also exhibited nematicidal activity against Meloidogyne incognita[64]. Erigeron canadensis showed insecticidal activity against Colletotrichum lindemuthianum (Sacc. & Magn.)[117]. In another study, Conyza bonariensis, C. canadensis and C. sumatrensis essential oils exhibited larvicidal activity against Aedes aegypti, Ae. albopictus and Culex quinquefasciatus[49]. Essential oils from C. discoridis and C. linifolia showed insecticidal activity against Culex pipiens[86] while Conyza linifolia essential oil was insecticidal against rice weevil Sitophilus oryzae[86].

The germination and growth of other plant species can be prevented by some secondary metabolites released by specific plants. Evaluation of such compounds in comparison to the currently utilized synthetic herbicides can lead to the discovery of new natural herbicides that are environmentally friendly or have new modes of action [118]. Some Conyza species have been reported to inhibit the growth of other plants. The herbicidal activity chemicals isolated from Conyza **dioscoridis** (L.) desf. leaves was tested on seeds of Convolvulus arvensis (L.), Portulaca oleracea (L.), Phalaris paradoxa (L.), Corchorus olitorius (L.) and Echinochloa crus-galli (L.)[119]. The active compounds were identified to be methyl 15-oxo-eudesome-4, 11(13)-diene 12-oate, 1α, 9α-dihydroxy-α-cyclocostunolide, isorhamnetin 3-sulfate, isorhamnetin 3-O-rutinoside, rhamanetin and epicatechin[119].

Other bioactivities exhibited by Conyza species include antidiabetic from C. dioscoridis[77], antiviral form C. Canadensis[68], anticonvulsant from C. bonariensis[120], anti-amnesic from C. bonariensis[66], antiamoebic and antigiardial from C. filaginoides[78].

III. Chemical Components of Conyza Species Essential oils

The major chemical components ((>5%) in essential oils obtained from 54 samples of Conyza species from different geographical locations is presented in Table 2. Most of the essential oils samples whose chemical composition reports were accessed belong to C. Canadensis (26, 47%), C. bonariencis (18, 33%), C. sumatrensis (4, 7%) and C. floribunda (4, 6%) species indication they are the most widely distributed. The samples from the aerial parts are the most (39 samples) investigated followed by leaves (9), roots (3) and flowers (1).

The major chemical compounds of essential oils found in most Conyza species were limonene and β-farnesene, which were found in 41 and 20 samples respectively. Other major componets are caryophyllene (12), spathulenol (12), β-ocimene (12), lachnophyllum ester (11), matricaria ester (10), germacrene D (11), α-bergamotene (8), caryophyllene oxide (9), pinene (6), bicyclogermacrene (5), curcumene (4), cadinene (3), sesquiphellandrene (2) and camphene (2). The rest of the components including 2,6,7,7a-tetrahydro-1,5-dimethyl-1H-indene-3-carboxaldehyde, 2-heptyl acetate, allo-aromadendrene, bisabolene oxide, carvacrol, cis-sabinol, *epi*-bicyclosesquiphellandrene, humulene, isoeugenol, isospathulenol, mentha-1,3,8-triene, myrcene, neophytadiene, perillaldehyde, phytol, pinocarveol, pulegone, Sabinene, terpinolene, zingiberene and β-copaen-4 α-ol were found in one sample each. The concentration of matricaria methyl ester ranged between 6.1 to 17.7% in most samples were it was detected but recorded very high concentration(88.2%) in essential oil from C. Canadensis root from Szeged, Hungary[91].

The reported bioactivities in extracts from Conyza plants can be attributed to the presence of the chemicals components which have reported to have various physiological activities. For example, limonene was determined to be antimicrobial, anti-inflammatory, antioxidant, anticancer and insecticidal[102,103]; caryophyllene and caryophyllene oxide is cytotoxic, anticancer, antioxidant and antimicrobial[121,122]; spathulenol is cytotoxic, antioxidant, anti-inflammatory, antiproliferative and antimycobacterial[123,124]; β-ocimene is cytotoxic and antileishmanial[125]; α-bergamotene is cytotoxici and antioxidant[126]; pinene is anti-inflammatory[127]; cadinene is antioxidant[128]; sesquiphellandrene was found to be anticancer[129] while camphene showed antioxidant, antibacterial, antifungal, anticancer, antioxidant, antiparasitic, antidiabetic, anti-inflammatory and hypolipidemic activities[130,131].

IV. Conclusion

Most previous studies were concentrated around establishing the antimicrobial, anti-inflammatory and antioxidant activities of the plant extracts despite the fact that the plants are used to manage a wide range of ailments in traditional medicine. In addition, only a few species from the genus have been evaluated for bioactivities and these include *C. bonariencis, C. canadensis, C. sumatrensis and C. floribunda*. Findings from this study shows that the major compounds in the essential oils of *Conyza* species are limonene, β-farnesene, caryophyllene, spathulenol, β-ocimene, lachnophyllum ester, matricaria ester, germacrene D, α-bergamotene, caryophyllene oxide, pinene, bicyclogermacrene, curcumene, cadinene, sesquiphellandrene and camphene. Despite the wide range of medicinal applications and the existence of over 200 species, only a few species have been subjected to scientific investigation. Further investigations especially on the understudied species is necessary.

Table 2. Major components of essential oils from some *Conyza species* from different locations

***Conyza* Species**	Plant Part	Collection Site	Major compounds (>5%)	Ref
C. bonariensis	Aerial parts EO	Chapada dos Guimarães, Mato Grosso, Brazil	Limonene (6.9%), (E)-caryophyllene (14.4%), (E)-β-farnesene (23.3%), Germacrene D (15.3%), bicyclogermacrene (8.3%), spathulenol (7.6%)	132
C. bonariensis	Aerial parts EO	Melgaço, Pará, Brazil	Limonene (22.9%), (*E*)-caryophyllene (13.3%), *trans*-α-bergamotene (5.3%), (*E*)-β-farnesene (20.1%), bicyclogermacrene (6.6%), spathulenol (6.3)	132
C. bonariensis	Aerial parts EO	Peixe-Boi, Pará, Brazil	(*E*)-Caryophyllene (13.3%), *trans*-α-bergamotene (8.1%), (*E*)-β-farnesene (30.9%)	132
C. bonariensis	aerial parts EO	alta Floresta, Mato Grosso, Brazil	Limonene (12.6%), (*E*)-caryophyllene (13.0%), (*E*)-β-farnesene (19.1%), germacrene D (13.2%), bicyclogermacrene (6.3%), spathulenol (5.7%)	132
C. bonariensis	Aerial parts EO	Macapá, Amapá, Brazil	Limonene (58.4%), (*E*)-β-farnesene (7.0%)	132
C. bonariensis	aerial parts EO	Rio de Janeiro, Brazil	Limonene (45.0%), (*E*)-β-ocimene (13.0%), (*E*)-β-farnesene (6.6%), Germacrene D (6.4%)	98
C. bonariensis	Leaf EO	Minas Gerais State, Brazil	Limonene (29.6%), *trans*-α-bergamotene (10.3%), matricaria methyl ester (8.3%), β-copaen-4 α-ol (7.4%)	133
C. bonariensis	Aerial parts EO	Athens, Greece	Limonene (8.3%), (*E*)-β-ocimene (11.5%), (*E*)-β-farnesene (8.1%), (*Z*)-lachnophyllum ester (21.2%), matricaria ester (17.7%	134
C. bonariensis	Aerial parts EO	Southwestern Misiones Province, Argentina	Limonene (13.5%), (E)-β-ocimene (13.3%), p-mentha-1,3,8-triene (5.2%), germacrene D (14.6%), bicyclogermacrene (6.6%)	135
C. bonariensis	Leaf EO	Monastir, Tunisia	Limonene (5.8%), terpinolene (5.3%), (*E*)-β-farnesene (7.5%), matricaria ester (17.8%), caryophyllene oxide (7.8%)	94
C. bonariensis	Aerial parts EO	Cagliari, Sardinia, Italy	Limonene (5.1%), carvacrol (9.8%), α-curcumene (10.2%), spathulenol (18.6%), caryophyllene oxide (18.7%), neophytadiene (6.1%)	136
C. bonariensis	Leaf EO	Mérida State, Venezuela	(*E*)-β-Farnesene (37.8%), (*E*)-β-ocimene (20.7%), β-sesquiphellandrene (9.8%), α-farnesene (5.6%), limonene (5.1%), (*Z*)-β-ocimene (5.1%)	104
C. bonariensis	Leaf EO	Kabianga, Kericho, Kenya	β-Pinene (5.4%), limonene (8.3%), 2,6,7,7a-tetrahydro-1,5-dimethyl-1*H*-indene-3-carboxaldehyde (49.1%)	62
C. bonariensis	Aerial parts EO	Parana State, Brazil	Limonene (66.3%), 2-heptyl acetate (6.9%)	137
C. bonariensis	Leaf EO	Dagni Koudzragan,Togo	β-Caryophyllene (16.19%), β-farnesene (15.53%), Limonene (12.75%), methyl *cis*-Lachnophyllum ester (9.76%), Germacrene-D (6.77%), β-ocymene (5.75%), γ-cadinene (5.34%)	64
C. bonariensis	Aerial parts EO	Tunisia	Caryophyllene oxide (18.7%), spathulenol (18.6%), α-curcumene.	136
C. bonariensis	Aerial parts EO	Sardinia, Italy	*cis*-Lachnophyllum ester (14.2%) and (*E*)-β-farnesene (12.0%).	136

C. bonariensis	Aerial parts EO		(*E*)-caryophyllene (13.3%), α-humulene (5.4%), *allo*-aromadendrene (41.2%), caryophyllene oxide (12.2%)	49
C. canadensis	Aerial parts EO	Plovdiv, Bulgaria	Limonene (77.7–89.4%)	138
C. canadensis	Aerial parts EO	Łód´z, Poland	Limonene (76.3%)	139
C. canadensis	Aerial parts EO	Alps, France	Limonene (83.2%)	139
C. canadensis	Aerial parts EO	Rome, Italy	Limonene (70.3%), **(***E***)**-β-ocimene (5.5%)	139
C. canadensis	Aerial parts EO	Seville, Spain	Limonene (51.4%), **(***E***)**-β-ocimene (13.4%), *trans*-α-bergamotene (11.9%)	139
C. canadensis	Aerial parts EO	Belgium	Limonene (68.0%), **(***E***)**-β-ocimene (5.1%), *trans*-α-bergamotene (5.4%), germacrene D (7.3%) **(***Z***,***Z***)**-matricaria ester (6.1%)	139
C. canadensis	Aerial parts EO	Plovdiv, Bulgaria	Limonene (87.9%)	139
C. canadensis	Aerial parts EO	Vilnius, Lithuania	Limonene (77.7%), trans-*α*-bergamotene (5.5%)	139
C. canadensis	Aerial parts EO	Israel	Limonene (54.9%), (Z)-β-farnesene (6.3%) (*Z*,*Z*)-matricaria ester (7.7%)	139
C. canadensis	Aerial parts EO	Kerman, Iran	Myrcene (8.9%), limonene (12.3%), **(***E***)**-β-farnesene (14.6%), curcumene (7.8%), zingiberene (5.5%), spathulenol (14.1%), isospathulenol (7.7%), phytol (7.3%)	140
C. canadensis	Aerial parts EO	Athens, Greece	β-Pinene (9.5%), limonene (57.3%), matricaria ester (14.4%)	134
C. canadensis	Aerial parts EO	Korea	Limonene (68.3%), **(***E***)**-β-ocimene (15.9%)	141
C. canadensis	EO	China	Limonene (14.8%), *epi*-bicyclosesquiphellandrene (11.0%), 1-phenyl-1-nonyne (7.3%)	142
C. canadensis	Aerial parts EO	Szeged, Hungary	Limonene (79.2%)	91
C. canadensis	Root EO	Szeged, Hungary	*2Z,8Z*-matricaria ester **(**88.2%)	91
C. canadensis	Aerial parts EO	Manavgat, Antalya, Turkey	β-Pinene (9.7%), limonene (28.1%), spathulenol (16.3%)	70
C. canadensis	Root EO	Manavgat, Antalya, Turkey	*cis*-Lachnophyllum ester (86.5%), (2*Z*,8*Z*)-matricaria ester (3.9%), β-pinene (2.3%) and spathulenol (2.0%)	70
C. canadensis	Aerial parts EO	Kashmir Valley, India	Limonene (23.78%), (*Z*)-lachnophyllum ester (21.25%), (*E*)-*β*-ocimene (16.02%), *β*-pinene (11.83%) and (*E*)-*β*-farnesene (7.84%).	71
C. canadensis	Aerial parts EO		Limonene (67.3%) and (*cis*,*cis*)- matricaria ester (9.2%)	143
C. canadensis	Aerial parts EO	West Japan	Limonene (31.2%), camphene (14.2%) and germacrene D (11.3%)	144
C. canadensis	Aerial parts EO	Ethiopia	Limomene (57.2%), camphene (β.5%) α and β-pinenes (1.9 % and 2.1%)] and sesquiterpenoids [caryophyllene (6.7%), germacrene D (4.9%) and α-curcumene (3.0%)]. β-Caryophyllene: 6.7%, Germacrene D: 4.9%	145
C. canadensis	Aerial parts EO	France	Limonene: 76.03%, delta-3- Carene: 3.87±0.03%, α-Santalene: 5.84%,	117
C. canadensis	Aerial parts EO	Poland	Limonene (70.0%) and *trans*-α-bergamotene (7.0%)	146
C. canadensis	Aerial parts EO		β-Pinene (8.8%), limonene (41.5%), (*Z*)-lachnophyllum ester (5.5%)	49
C. canadensis	Leaf EO	Naviraí, Mato Grosso Brazil	Limonene (38.0%), caryophyllene oxide (22.3%), spathulenol (10.7%)	72
C. canadensis	Root EO	Naviraí, Mato Grosso Brazil	Lachnophyllum methyl ester (91.6%), matricaria methyl ester (6.7%)	72
C. sumatrensis	Aerial parts EO	Rondônia state, Brazil	Sabinene (5.3%), limonene (22.9%), (*E*)-β-ocimene (5.0%), (*E*)-β-farnesene (5.3%), (*Z*)-lachnophyllum ester (43.7%)	147
C. sumatrensis	Leaf EO	N'gorato village, Côte d'Ivoire	Limonene (13.0%), (*E*)-β-ocimene (6.5%), (*E*)-caryophyllene (10.5%), (*E*)-β-farnesene (17.0%), (*Z*)-lachnophyllum ester (5.9%), germacrene D (13.6%), bicyclogermacrene (5.2%)	148
C. sumatrensis	Leaf EO	Monastir, Tunisia	Matricaria ester (7.5%), spathulenol (13.8%), caryophyllene oxide (20.5%)	149
C. sumatrensis	Aerial parts EO		Limonene (25.5%), (*E*)-caryophyllene (5.5%), (*E*)-β-farnesene (6.7%), (*Z*)-lachnophyllum ester (20.7%), spathulenol (5.2%), caryophyllene oxide (5.8%)	49

C. dioscoridis	Aerial parts EO	Cairo, Egypt	(±)-Cadinene (10.79), berkheyeradulene (9.84), δ-cadinene (9.84), trans-Z-α-Bisabolene oxide (8.16), 5-epi-shyobunol (5.94), caryophyllene (4.82), α-guaiene (4.64), and α-cadinol (4.54).	77
C. linifolia	Aerial parts EO	Egypt	α-Bergamotene (27.4%) and D-limonene (22.5%)	86
E. floribundus	Leaf EO	Cameroon	(Z)-2-Lachnophyllum ester (23.7-26.2%), (E)-β-farnesene (14.6-16.4%), β -caryophyllene (14.7-16.6%) and limonene (9.5-11.4%).	92
E. floribundus	Flower EO	Cameroon	(E)-β-Farnesene (22.3- 24.1%), β-caryophyllene (17.3-20.1%) and germacrene D (10.1-11.0%)	92
E. floribundus	Aerial parts EO	Dschang, West Province of Cameroon	Caryophyllene oxide (12.4%) and spathulenol (12.2%), and (*E*)-β-farnesene (5.5%) and (*E*)-caryophyllene (4.2%),	83
C. filaginoides	Aerial parts EO	Mexico	*trans*-Pinocarveol (11.5%), (Z)-3-hexen-1-ol (11.6%), cis-sabinol (9.9%), caryo-phyllene oxide (8.7%), pulegone (7.1%), isoeugenol (6.8%), *o*-cymene (5.1%), perillaldehyde.	79

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