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Phytochemistry and some biological activities of the Genus Hypericum

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ABSTRACT

Medicinal plants are the best source of medicine. Therefore, studies on these plants have increased because of the search for new active substances that can be used in the herbal pharmaceutical industries. Hypericum is a large genus of flowering plants, comprising many species, and presents an almost worldwide distribution. The importance of its species depends mainly on the presence of specialized secondary metabolites that display pharmaceutical and cosmetic properties. Hypericum species are known worldwide for their ethno-medicinal uses including treating infections and diseases. They are used as diuretics, cholagogues, antispasmodics, antiepileptics, and also for treating rheumatism, neuralgia, parasites, dyspepsia, diarrhea, etc. There are only few reports about the chemical composition of the genus Hypericum. The aim of the present study is to provide an overview of the importance of the genus Hypericum. A summary of the chemical composition, as well as the antibacterial and antioxidant activities of different Hypericum species.

1. Introduction

In developing countries, 70-95% of people depend on plants as their main method of treatment these days [1]. According to the WHO, medicinal plants are the best source of medicines [2]. Some researchers believed that two-thirds of the world's plants are medically beneficial [3]. Therefore, research on medicinal plants has increased rapidly in order to find new active substances that can be used in herbal medicine industries [2].

On the other hand, the problem of food preservation is becoming more complex, requiring a longer shelf life and greater protection from microbial spoilage and oxidative damage. Some statistics indicated that about 30% of people in industrialized countries suffer annually from foodborne [4].

Medicinal plants are considered as powerful and easily available sources of antioxidants, due to the chemical compounds they contain that act individually or synergistically to treat diseases [5]. It has been reported that many phenolic compounds such as procyanidins, coumarins, flavonoids and tannins can scavenge radicals -in a dose-dependent manner- and are thus

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considered as therapeutic medicines for free radical diseases [6].

Medicinal plants also contain compounds that may inhibit the growth of viruses, protozoa, bacteria and fungi by various mechanisms and this can be of a significant clinical value in treating of resistant microbial strains [7]. These bioactive compounds are used as a starting point for the synthesis of antibiotics in order to treat infectious diseases [8]. In general, the extent of the antioxidant and antimicrobial effects of the extracts could be attributed to their phenolic compounds [9].

Hypericum is a large genus of flowering plants, including many species [10], and presents an almost worldwide distribution. The importance of its species depends mainly on the presence of specialized secondary metabolites that display pharmaceutical and cosmetic properties [11]. Over the years, there has been a great interest in studying the different biological activities of Hypericum species [10]. Therefore, the purpose of this study is to provide an overview of the importance of Hypericum. A summary of the typical essential oil constituents, as well as the antibacterial and antioxidant activities of different species belonging to the genus Hypericum.

2. The genus Hypericum

Hypericaceae family contains shrubs or herbaceous plants. They have glandular hairs that contains essential oils (EOs) [12]. This family includes nine genera, one of which is Hypericum [13]. Hypericum contains nearly 500 species [14], perennial, herbaceous, or scrubby plants [15], widely distributed in mountainous, tropical and temperate regions [16]. The genus received a great as it is a source of a variety of compounds with various biological effects [15].

Hypericum species are globally recognised for their significant ethno-medicinal properties, which are utilised in the treatment of various infections and diseases [17]. These species exhibit a wide range of therapeutic effects, including diuretic, cholagogue, antispasmodic, antiepileptic, and antimigraine properties. Additionally, they are employed in the management of conditions such as rheumatism, neuralgia, parasitic infections, dyspepsia, sciatica, and diarrhea [13]”. Hypericum plants have been included in Pharmacopoeias of many countries such as Germany, Czechoslovakia, Russia, Romania, Poland and France [18]. Various products containing Hypericum plants or their extracts have been developed as additives and many brands such as beverages and yogurts include these plants [18].

The biological effects of the plants depend on their contents of secondary metabolites [19]. The chemical content of Hypericum plants is diverse with xanthones, glycosides, pyrones, flavonoids, tannins, anthraquinones, lactones, lipids, phloroglucinols, coumarins and EOs [20].

The major phytomedicinal compounds of Hypericum species are naphthodianthrones (hypericin and pseudohypericin), phloroglucinol derivatives (adhyperforin and hyperforin), flavonoids (rutin, biapigenin, hyperoside, quercetin, quercitrin), chlorogenic acid and caffeic acid which possess many biological properties [14].

Hypericum perforatum is one of the most widely used medicinal plants -among all species of the genus Hypericum- by the publics of both more industrialized and less developed countries [21]. It is used as a mild antidepressant [22]. This effect of H. perforatum is due to its main component hyperforin. The combined effect of the other components within the plant extract also contributes to its overall impact synergistically [19].

3. Chemical Composition of the Essential Oils of Hypericum Species

The volatile substances in plants are generally analyzed through extraction steps, concentration, chromatography and detection steps [23]. Hypericum plants are generally known to be poor in essential oil (generally oil yield <1%, w/w) [18].

***Table 1**. Chemical composition of Hypericum essential oils*

.

Species	Plant part	Main compounds	Ref.
H. elegans	AE	g-gurjunene, aromadendrene, and undecane	
H. tetrapterum	AE	Copaene, α -longipinene, cadinene	
H. hirsutum	AE	caryophyllene oxide, phytol, α - caryophyllene and undecane	[24]
H. perforatum	AE	ß – caryophyllene, caryophyllene oxide, α -pinene, ß -cadinene, and ß -pinene	
H. scabrum	AE	α-pinene, β-caryophyllene, myrcene, cadalene and β-pinene	[25]
H. scabroides	AE	hexadecanoic acid, spathulenol, nonacosane, dodecanoic acid, baeckeol and γ-muurolene	
H. kotschyanum	AE	α-pinene, nonacosane, hexadecanoic acid, β-pinene, spathulenol and limonene	[26]
H. salsugineum	AE	nonacosane, hexadecanoic acid and baeckeol	
H. thymopsis	AE	α-pinene, baeckeol, spathulenol, limonene and camphene	
H. uniglandulosum	AE	2,6-Dimethyl-3,5-heptadien-2-one, nonacosane, hexadecanoic acid and α-pinene	
H. uniglandulosum	AE	α-pinene, undecane, benzoic acid, cyclohexasiloxane	[27]
H. lydium	AE	α-pinene, ß-pinene, ß-myrcene	
H. thymopsis	AE	α-pinene, spathulenol, limonene	[28]
H. perforatum	AE	(germacrene D); ((E)-caryophyllene); (2-methyloctane); (α-pinene) and (bicyclogermacrene)	[29]
H. perforatum	FL	(E- ß –farnesene); (n-hexadecanal); (E-nerolidol)	
H. dogonbadanicum	FL	(phenyl ethyl octanoate); (terpin-4-ol); (α-phellandrene)	
	LE	ß-pinene, α-pinene and p-cymene	
H. helianthemoides	FL	α -pinene, Z- ß -ocimene and ß -pinene	
H. hyssopifolium	FL	α -pinene, ß -pinene and n-tetradecan	[30]
	LE	E-nerolidol, n-tetradecane and α -himachalene	
H. lysimachioides	FL	α-pinene, Z- ß -ocimene and n-tetradecane	
H. triquetrifolium	FL	n-tetradecane, α -himachalene and α –pinene	
	LE	α -himachalen, n-tetradecane and n-pentadecane	
H. triquetrifolium	AE	Germacrene-D, ß -caryophyllene, δ -cadinene, trans- ß -farnesene, α -humulene, ß -selinene, γ-cadinene and trans-phytol	[31]
H. richeri	AE	germacrene D, bicyclogermacrene, α-pinene, ß-pinene, decanoic acid, ß -caryophyllene, δ-cadinene, spathulenol and tetracosane	[32]
H. patulum	AE	β-pinene, α-pinene, limonene and α-humulene	[33]
H. laricifolium	AE	and nonane α-pinene, verticiol, 3-methyl-nonane, 2-methyl-octane	[13]
H. rumeliacum	AE	undecane, dodecanal, and germacrene D	[34]
H. rumeliacum	AE	(E)-β-ocimene, β-pinene, (Z)-β-ocimene, dodecanal, germacrene D, myrcene	[35]
H. rumeliacum	AE	α-pinene, ß-pinene, dehydro-aromadendrene, α-copaene	[36]
H. lydium	AE	α -pinene, β-pinene and β-myrcene	[27]

H. ericoides	AE	n-nonane, n-undecane, α-cubebene, α-pinene	[18]
H. androsaemum	AE	longifolene, ß-gurjunene, and γ-gurjunene	[22]
H. apricum	AE	cis-piperitol acetate, p-cymenene, α-pinene	
H. armenum	AE	γ -cadinene, longifolene, E-nerolidol	
H. asperulum	AE	α -muurolol, cis-sesquisabienen hydrate, germacrene B	
H. hirsutum	AE	germacrene B, citronellyl propanoate, γ –gurjunene	
H.linarioides	AE	(E, E)-farnesyl acetate, cis-cadinene ether, 1-tridecene	
H. tetrapterum	AE	trans-linalool oxide, p-cymenene, (E, E)-farnesyl acetate	
H. vermiculare	AE	α -pinene, myrcyne, E- ß -farnesene	
H. asperulum	AE	(α-pinene); (caryophyllene oxide); (E-caryophyllene) and (spathulenol)	[37]
H. scabrum	AE	(α-pinene); (β-pinene); (limonene) and (E-caryophyllene)	
H. vermiculare	AE	(α-pinene); (caryophyllene oxide); (E-caryophyllene) and (spathulenol)	
H. pseudolaeve	AE	(trans-caryophyllene); (δ-limonene); (α-cadinol); (caryophyllene oxide); (α-pinene); (spathulenol) and (β-selinene)	[38]
H. thymbrifolium	AE	α-pinene, undecane, germacrene D, β-pinene, β-myrcene, spathuleneol, naphthalane	
H. humifusum	AE	(n-undecane); (α-pinene); (β-pinene); (limonene); (myrcene)	[18]
H. bupleuroides	AE	(β-sesquiphellandrene); (β-caryophyllene); (selina-3,7(11)-diene); (γ-elemene); (undecane); (germacrene-B)	[20]
H. gaitii	AE	α-pinene, allo-aromadendrene, δ-cadinene, n-nonane, β-caryophyllene, α-selinene	[39]
H. mexicanum	AE	n-nonane, α-pinene	[40]
H. myricariifolium	AE	α-pinene, β-caryophyllene	
H. juniperinum	AE	n-nonane, α-pinene, geranyl acetate, and β-caryophyllene	
H. heterophyllum	AE	germacrene-D, bicyclogermacrene, d-cadinene, spathulenol, a-guaiene, and valencene	[41]
H. amblysepalum	AE	δ -3-carene, caryophyllene-oxide, cis-ocimene, ß-caryophyllene, α-pinene	[42]
H. spectabile	AE	ß - caryophyllene, germacrene D, α-cadinol, caryophyllene oxide	
H. helianthemoides	AE	α-pinene, δ -3-carene, d-limonene, cis-ocimene, undecane	
H. acmosepalum	AE	(ar-curcumene); (β-selinene)	[43]
H. beanii	AE	(γ-muurolene); (β-selinene); (caryophyllene oxide)	
H. calycinum	AE	α-terpineol, P-pinene	
H. choisyanum	AE	cis-eudesma-6,11-diene	
H. forrestii	AE	a-pinene, caryophyllene oxide	
H. kouytchense	AE	cis-β-guiaene, γ-muurolene	
H. lancasteri	AE	β-selinene, eudesmadienone	
H. leschenaultii	AE	(Cuparene) and (γ-muurolene)	
H. monogynum	AE	Tricosane, myrcene	
H. patulum	AE	β-selinene	
H. pseudohenryi	AE	β-selinene	
H. X moserianum	AE	γ-muurolene, δ-cadinene	
H.salsolifolium	AE	α-pinene, limonene, spathulenol, β-pinene, germacrene D	[44]
H.retusum	AE	α-pinene, limonene, spathulenol, β-pinene, germacrene D	
H. maculatum	-	β-farnesene, n-undecane, β-caryophyllene, δ-cadinene, muurolene	[45]
H. foliosum	-	n-nonane, limonene, terpinolene, β–caryophyllene, β-pinene	[46]
H. brasiliense	WP	ß-Caryophyllene, α-Humulene, Caryophyllene oxide, Cubenol, aromadendrene	[47]

AE: Aerial parts; FL: flower; LE: leaf; WP: whole plant

The essential oil (EO) composition of about 50 different Hypericum species have so far been identified [26]. The main components of some Hypericum species EOs are presented in Table 1. Some components were detected in more than one species, such as α –pinene was identified in the EO of H. vermiculare, H. pseudolaeve, H. thymbrifolium, H. humifusum, H. ericoides, H. apricum, H. laricifolium, H. lydium, H. richeri, H. patulum, H. lysimachioides, H. triquetrifolium, H. dogonbadanicum, H. helianthemoides, H. hyssopifolium, H. uniglandulosum, H. kotschyanum, H. thymopsis, H. perforatum, H. scabrum. Whereas β-Pinene was identified in the EO of H. humifusum, H. lydium, H. richeri, H. patulum, H. thymbrifolium, H. dogonbadanicum, H. helianthemoides, H. hyssopifolium, H. kotschyanum, H. perforatum, H. scabrum. Undecane was also introduced as one of the main compounds of H. bupleuroides, H. thymbrifolium, H. humifusum, H. ericoides, H. hirsutum, H. rumeliacum, H. elegans EOs. Spathuleneol was also identified in the EOs of H. pseudolaeve, H. thymbrifolium, H. kotschyanum, H. richeri, H. thymopsis, H. scabroides. hexadecanoic acid was identified in the EOs of H. scabroides, H. uniglandulosum, H. kotschyanum, H. salsugineum.

In contrast, some compounds were detected as main constituents in the unique species, such as copaene in the EO of H. tetrapterum, α-muurolol in the EO of H. asperulum, cis-piperitol acetate in the EO of H. apricum and verticiol in the EO of H. laricifolium.

Previous investigations on the EO composition of Hypericum plants did not give homogenous results. These studies have shown that this variance depends on genetics and environment, ontogeny, season, analytical method [48], geographical distribution, type of glands and phenological cycle [32].

For instance, the H. perforatum EO extracted from aerial parts obtained from the Republic of Moldova contained ß–caryophyllene, caryophyllene oxide, α–pinene, ß–cadinene, and ß– pinene in the following percentages (12.175%,12.119%, 8.574%, 4.155%, 3.216%), respectively [24], while another H. perforatum EO extracted from aerial parts obtained from southeastern Serbia showed germacrene D, (E)-caryophyllene, 2- methyloctane, α-pinene, bicyclogermacrene and (E)- β-ocimene as main volatile constituents in the following percentages (18.6%, 11.2%, 9.5%, 6.5%, 5.0%, 4.6%), respectively [29].

The variability of the EOs composition depend also on the part analyzed [48]. For instance, the flowers oil of H. dogonbadanicum was dominated by phenyl ethyl octanoate, terpin-4-ol, and α-phellandrene, whereas the oil from the leaves of the same plant had α-pinene, ß-pinene and p-cymene as its main compounds.

The flowers oil of H. hyssopifolium was quite different from the leaves oil. α -pinene, ß -pinene and n-tetradecan were the main compounds of the flowers oil, where the leaves contained E-nerolidol, n-tetradecane and α -himachalene.

4. Chemical Composition

This review summarizes the chemical constituents from the genus Hypericum which are mainly responsible for its pharmacological benefits. We documented about 100 different natural products and 34 different plant species as sources for these natural products (Table 2). Most of the chemical constituents were mainly isolated from the aerial parts and a few from roots and fruits. The isolated compounds are in the class of phenolic compounds, flavonoids and its glycosides, phloroglucinols, triterpenoid, benzophenones, naphthodianthrone. Flavonoids were the most abundant among the isolated compounds. Hypericum species were also characterized by containing several compounds of the xanthones class.

According to this survey, quercitin, rutin, hypericin, isoquercitrin, quercetrin, chlorogenic acid, pseudohypericin and I3–II8 Biapigenin are the most abundant among secondary metabolites isolated from Hypericum species. The pharmacological researches mainly focus on flavonoids such as rutin, hyperoside, and quercetin, and naphthodianthrones such as hypericin.

Table 2. *Compounds isolated from Hypericum species*

Compound	**Plant species**	**Plant part**	**Ref.**
Phenolic compounds			
3-geranyl-1-(2'-methylbutanoyl) phloroglucinol	*H. scruglii*	AE	[49]
	H. empetrifolium	FR	[50]
3-geranyl-1-(2'-methylpropanoyl) phloroglucinol	*H. scruglii*	AE	[49]
	H. empetrifolium	FR	[50]
3-(13-hydroxygeranyl)-1-(2'-methylbutanoyl) phloroglucinol	*H. scruglii*	AE	[49]
adhyperfoliatin	*H. trichocaulon*	AE	[51]
(E)-chlorogenic acid	*H. trichocaulon*	AE	
procyanidin A2	*H. trichocaulon*	AE	
Uliginosin B	*H. caprifoliatum*	AE	[52]
	H. denudatum	AE	
	H. polyanthemum	AE	
Uliginosin A	*H. brasiliense*	LE - FL	[53]
Isouliginosin B	*H. denudatum*	AE	[52]
	H. polyanthemum	AE	
	H. brasiliense	LE - FL	[53]
Hyperbrasilol B	*H. austrobrasiliense*	AE	[52]
	H. caprifoliatum	AE	
	H. pedersenii	AE	
Hyperbrasilol A	*H. brasiliense*	LE - FL	[53]
	H. denudatum	AE	[52]
Isohyperbrasilol B	*H. caprifoliatum*	AE	
	H. pedersenii	AE	
Austrobrasilol B	*H. austrobrasiliense*	AE	
	H. caprifoliatum	AE	
	H. pedersenii	AE	
Isoaustrobrasilol B	*H. austrobrasiliense*	AE	
Austrobrasilol A	*H. austrobrasiliense*	AE	
	H. caprifoliatum	AE	
	H. pedersenii	AE	
	H. denudatum	AE	
Denudatin A	*H. denudatum*	AE	
Japonicine A	*H. caprifoliatum*	AE	
	H. pedersenii	AE	
	H. brasiliense	LE - FL	[53]

hengshanols A	*H. hengshanense*	AE	[54]
Hyperforin	*H. perforatum*	-	[55]
	H. perforatum	FLS	[56]
	H. humifusum	AE	[57]
	H. confertum	FL	[58]
	H. pruinatum	FL	
	H. lydium	FL	
adhyperforin	*H. confertum*	FL	
	H. pruinatum	FL	
	H. lydium	FL	
1-(6-hydroxy-2,4-dimethoxyphenyl)-2-methyl-1-propanone	*H. cistifolium*	AE	[59]
hydroquinone	*H. lanceolatum*	STB	[60]
3-O-Caffeoylquinic acid (chlorogenic acid)	*H. richeri*	AE	[61]
	H. perforatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	LE- FL	
	H. perforatum	FLS	[56]
4-O-Caffeoylquinic acid	*H. barbatum*	AE	[61]
5-O-Caffeoylquinic acid	*H. richeri*	AE	
	H. barbatum	AE	
	H. perforatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	

Neochlorogenic acid	*H. confertum*	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	LE- FL	
	H. lydium	ST- LE- FL	
caffeic acid	*H. confertum*	LE- FL	
	H. thymifolium	FL	
	H. linarioides	FL	
	H. pruinatum	LE- FL	
2,4-dihydroxybenzoic acid	*H. confertum*	ST- LE- FL	
	H. thymifolium	LE- FL	
	H. linarioides	LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	FL	
	H. scabrum	LE- FL	
	H. lydium	FL	
3,4-dihydroxybenzoic acid	*H. scruglii*	*AE*	[49]
Quinic acid	*H. perforatum*	FLS	[56]
3-p-Coumaroylquinic acid	*H. perforatum*	FLS	
3-Feruloylquinic acid	*H. perforatum*	FLS	
Flavonoids			
amentoflavone	*H. confertum*	LE- FL	[58]
	H. thymifolium	FL	
	H. linarioides	LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	LE- FL	
	H. scabrum	FL	
	H. lydium	LE- FL	
Rutin (quercetin 3-O-rutinoside)	*H. perforatum*	FLS	[56]
	H. triquetrifolium	AE	[62]

	H. richeri	AE	[61]
	H. perforatum		
	H. hirsutum		
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. trichocaulon	AE	[51]
	H. calycinum	-	[63]
Hyperoside (quercetin 3-O-galactoside)	*H. perforatum*	FLS	[56]
	H. trichocaulon	AE	[51]
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. brasiliense	LE - FL	[53]
	H. ternum	-	[64]
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. calycinum	-	[63]

Quercitrin (quercetin 3-O-rhamnoside)	*H. perforatum*	FLS	[56]
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	LE	
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. trichocaulon	AE	[51]
	H. brasiliense	LE - FL	[53]
	H. calycinum	-	[63]
Isoquercitrin	*H. richeri*	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. ternum	-	[64]
	H. brasiliense	LE - FL	[53]
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	

	H. lydium	ST- LE- FL	
	H. calycinum	-	[63]
Quercetin	*H. perforatum*	FLS	[56]
	H. hyssopifolium	AE	[65]
	H. confertum	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. brasiliense	LE - FL	[53]
	H. laricifolium	AE	[66]
	H. lanceolatum	FL	[67]
	H. coadunatum	AE	[68]
	H. calycinum	-	[63]
Quercetin 3-methyl ether	*H. ternum*	-	[64]
3,7-dimethyl ether Quercetin	*H. ternum*	-	
arabinofuranoside Quercetin-3-O-α-l	*H. hyssopifolium*	AE	[65]
Quercetin-3-O-ß-d-galactopyranoside	*H. hyssopifolium*	AE	
Quercetin-3-O-ß-d-galactopyranoside-7-O-ß-d-glucopyranoside	*H. hyssopifolium*	AE	

Avicularin	*H. confertum*	ST- LE- FL	[58]
	H. thymifolium	ST- LE	
	H. linarioides	ST- LE- FL	
	H. pruinatum	LE- FL	
	H. olivieri	FL	
	H. scabrum	FL	
	H. lydium	FL	
Catechin	*H. confertum*	ST- LE- FL	
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. perforatum	FLS	[56]
	H. calycinum	-	[63]
Epicatechin	*H. confertum*	ST- LE- FL	[58]
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. calycinum	-	[63]
	H. perforatum	FLS	[56]
Amentoflavone	*H. perforatum*	FLS	
	H. confertum	LE- FL	[58]
Cyanidin 3-O-glycoside	*H. perforatum*	FLS	[56]
Cyanidin 3-O-rhamnoside	*H. perforatum*	FLS	
miquelianin	*H. calycinum*	-	[63]
myricitrin	*H. trichocaulon*	AE	[51]

myricetin	*H. lanceolatum*	FL	[67]
orientin	*H. coadunatum*	AE	[68]
	H. hirsutum	AE	[61]
2"-O-Acetyl-orientin	*H. hirsutum*	AE	
I3–II8 Biapigenin	*H. perforatum*	FLS	[56]
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. lanceolatum	FL	[67]
	H. hyssopifolium	AE	[65]
	H. trichocaulon	AE	[51]
	H. ternum	-	[64]
	H. calycinum	-	[63]
Myricetin 3-O-rutinoside	*H. richeri*	AE	[61]
Myricetin 3-O-galactoside	*H. richeri*	AE	
Myricetin 3-O-glucoside	*H. richeri*	AE	
luteolin	*H. brasiliense*	LE - FL	[53]
Kaempferol 3-O-rutinoside	*H. perforatum*	FLS	[56]
kaempferol-3-O-β-Dglucopyranoside	*H. lanceolatum*	FL	[67]
kaempferol	*H. brasiliense*	LE - FL	[53]
friedelanone	*H. lanceolatum*	FL	[67]
friedelan-3-β-ol	*H. lanceolatum*	FL	
B-type procyanidin dimer	*H. perforatum*	FLS	[56]
	H. perforatum	FLS	
	H. perforatum	FLS	
Procyanidin trimer	*H. perforatum*	FLS	

8-C- β-L- arabinopiranosylapigenin	*H. coadunatum*	AE	[68]
guaijaverin	*H. coadunatum*	AE	
	H. ternum	-	[64]
	H. brasiliense	LE - FL	[53]
Hovetrichoside C	*H. coadunatum*	AE	[68]
Naphthodianthrone			
Hypericin	*H. triquetrifolium*	AE	[62]
	H. perforatum	FLS	[56]
	H. perforatum	-	[55]
	H. humifusum	AE	[57]
	H. confertum	LE- FL	[58]
	H. thymifolium	LE- FL	
	H. linarioides	LE- FL	
	H. pruinatum	LE- FL	
	H. olivieri	LE- FL	
	H. scabrum	FL	
	H. lydium	LE- FL	
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. hyssopifolium	AE	[65]
Protopseudohypericin	*H. perforatum*	FLS	[56]
Pseudohypericin	*H. perforatum*	FLS	
	H. confertum	LE- FL	[58]
	H. thymifolium	LE- FL	
	H. linarioides	LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	LE- FL	

	H. scabrum	FL	
	H. lydium	LE- FL	
	H. richeri	AE	[61]
	H. perforatum	AE	
	H. barbatum	AE	
	H. acutum	AE	
	H. maculatum	AE	
Terpenoid derivatives			
2-benzoyl-3,3-dimethyl-4R,6S-bis-(3-methylbut-2-enyl)-cyclohexanone	*H. galioides*	AE	[59]
2-benzoyl-3,3-dimethyl-4*S*,6*R*-bis-(3-methylbut-2-enyl)-cyclohexanone	*H. galioides*	AE	
betulinic acid	*H. lanceolatum*	STB	[69]
	H. lanceolatum	STB - TW	[70]
ursolic acid	*H. lanceolatum*	STB - TW	
Benzophenones			
2,2',5,6'-tetrahydroxybenzophenone	*H. lanceolatum*	STB	[69]
isogarcinol	*H. lanceolatum*	FL	[67]
Hyperibone	*H. coadunatum*	AE	[68]
Xanthone			
5-hydroxy-3-methoxyxanthone	*H. lanceolatum*	STB	[69]
6,7-dihydroxy-1,3-dimethoxyxanthone	*H. lanceolatum*	STB	[60]
1,3,5,6-tetrahydroxy-4-prenylxanthone	*H. lanceolatum*	STB	
3-hydroxy-5-methoxyxanthone	*H. lanceolatum*	STB	[69]
	H. lanceolatum	STB	[60]
1,6-dihydroxyxanthone	*H. lanceolatum*	STB - TW	[70]
euxanthone	*H. lanceolatum*	FL	[67]
norathyriol	*H. lanceolatum*	STB - TW	[70]

1,7-dihydroxyxanthone	*H. laricifolium*	AE	[66]
1,3,8-trihydroxy-2-methoxyxanthone	*H. laricifolium*	AE	
1,3-dihydroxy-2-methoxyxanthone	*H. laricifolium*	AE	
1,3-dihydroxy-6-methoxy-xanthone	*H. laricifolium*	AE	[71]
2,8-dihydroxy-1-methoxyxanthone	*H. laricifolium*	AE	[66]
3,8-dihydroxy-1,2-dimethoxyxanthone	*H. laricifolium*	AE	
1-hydroxy-7-methoxyxanthone	*H. laricifolium*	AE	[71]
2-hydroxy-xanthone	*H. laricifolium*	AE	
6-deoxyisojacareubin	*H. laricifolium*	AE	
1,5,6-trihydroxy-7-methoxy-xanthone	*H. laricifolium*	AE	
hyperixanthone A	*H. trichocaulon*	AE	[51]
5-O-methyl-2-deprenylrheediaxanthone B	*H. roeperanum*	RO	[72]
5-O-methylisojacareubin	*H. roeperanum*	RO	
5-O-demethylpaxanthonin	*H. roeperanum*	RO	
roeperanone	*H. roeperanum*	RO	
Dimethylmangiferin	*H. perforatum*	FLS	[56]
3,6-Dihydroxy-1,5,7-trimethoxy-xanthone	*H. perforatum*	RO	
Cadensin C	*H. perforatum*	RO	
Cadensin C isomer	*H. perforatum*	RO	
γ-Mangostin	*H. perforatum*	RO	
5-O-Methyl-2-deprenylrheediaxanthone B	*H. perforatum*	RO	
Cadensin G	*H. perforatum*	RO	
Garcinone C	*H. perforatum*	RO	

AE: Aerial parts; ST: Stem; FL: flowers; LE: leaves; FR: Fruits; TW: twigs; RO: roots; STB: stem bark; FLS: Flower shoot.

5. Antimicrobial activity of *Hypericum* species

Microorganisms are present in the environment. Therefore, they can easily access food [73] with the problem of developing resistance, other problems such as high cost and side effects motivated researchers to look for alternative sources of antimicrobial agents, especially plants and plant products [74]. The genus *Hypericum*. These days, drug-resistant bacteria are rapidly emerging all over the world and pose a threat to the efficiency of antibiotics [75]. Along has been found to produce compounds that have antimicrobial properties [15]. Many studies have been conducted in many countries showing the antibacterial effect of this genus (table 3).

Methanolic extracts of six *Hypericum* species (*H. perforatum, H. neurocalycinum, H. spectabile, H. thymbrifolium, H. malatyanum* and *H. pseudolaeve*) were screened for antibacterial effect against many microorganisms. All extracts displayed antibacterial effect against *Staphylococcus aureus* ATCC 6538, *Staphylococcus epidermidis* ATCC 12228 and Methicillin-resistant *Staphylococcus aureus* ATCC33591, with MIC values ranged from 4.8 µg/ml to 156 µg/ml.

Boga et al., (2016) [76] evaluated the antibacterial effect of many extracts of the whole plant of *H. capitatum* var. *capitatum* against *Staphylococcus aureus* ATCC25923, *Escherichia coli* ATCC 25922, *Streptococcus pyogenes* ATCC19615, and *Pseudomonas aeruginosa* ATCC27853. The acetone and methanolic extracts were active on all tested microorganisms. The methanolic extract showed highest effect against *Escherichia coli* with an MIC value of 10 µg/ml [76].

Tchakam et al., (2012) [77] investigated the antibacterial effect of the methanolic extract of *H. lanceolatum* leaves. The extract showed antimicrobial activity against *Pseudomonas aeruginosa* ATCC 27853, *Klebsiella pneumonia* ATCC 13883, *Salmonella typhi* ATCC 6539, *Enterococcus faecalis* ATCC 10541, with MIC values ranged from 32 µg/ml to 64 µg/ml [77]. According to the published literature, the antibacterial activity varies according to the plant part. This is because the concentration of secondary metabolites accumulated in the plant cells varies according to the plant parts [78]. Antimicrobial activity of different parts (leaf, stem and flower) of *H. montbretii* and *H. bupleuroides* was determined using disc diffusion methods against several microbial species (*Bacillus subtilis* ATCC 6633, *Staphylococcus epidermidis* ATCC 12228, *Escherichia coli* ATCC 25922, and *Staphylococcus aureus* ATCC 25923). The results showed that the extracts displayed good-moderate antimicrobial effect, with MIC values ranged between (0.20-100)µg/ml.

Table 3. *Antibacterial effect of some Hypericum Species against various bacterial strains*

Species	Extract/ plant part	Micro-organisms	MIC (mg/ml)	Ref.
H. perforatum	Total methanol / AE	*S. aureus* (ATCC 6538)	0.0048	[75]
		Methicillin-resistant S. aureus (ATCC33591)	0.039	
		S. epidermidis (ATCC 12228)	0.078	
H. spectabile	Total methanol / AE	*S. aureus* (ATCC 6538)	0.0048	
		Methicillin-resistant S. aureus (ATCC33591)	0.0048	
		S. epidermidis (ATCC 12228)	0.039	
H. pseudolaeve	Total methanol / AE	*S. aureus* (ATCC 6538)	0.019	
		Methicillin-resistant S. aureus (ATCC33591)	0.156	
		S. epidermidis (ATCC 12228)	0.078	
H. thymbrifolium	Total methanol / AE	*S. aureus* (ATCC 6538)	0.039	
		Methicillin-resistant S. aureus (ATCC33591)	0.0048	
		S. epidermidis (ATCC 12228)	0.0048	
H. neurocalycinum	Total methanol / AE	*S. aureus* (ATCC 6538)	0.0048	
		Methicillin-resistant S. aureus (ATCC33591)	0.0048	
		S. epidermidis (ATCC 12228)	0.0048	
H. malatyanum	Total methanol / AE	*S. aureus* (ATCC 6538)	0.0048	
		Methicillin-resistant S. aureus (ATCC33591	0.0048	
		S. epidermidis (ATCC 12228)	0.0048	
H. jovis	EO/	*B. cereus* (human isolate)	0.0075	

	AE	*S. aureus* (ATCC 11632)	0.015	[79]
		E. coli (ATCC 25922)	0.0015	
		P. aeruginosa (ATCC 27853)	0.0015	
H. empetrifolium	EO/ AE	*B. cereus* (human isolate)	0.015	
		S. aureus (ATCC 11632)	0.030	
		E. coli (ATCC 25922)	0.010	
		P. aeruginosa (ATCC 27853)	0.005	
H. amblycalyx	EO/ AE	*B. cereus* (human isolate)	0.0025	
		S. aureus (ATCC 11632)	0.015	
		E. coli (ATCC 25922)	0.0025	
		P. aeruginosa (ATCC 27853)	0.0025	
H. androsaemum	Methanol (100%)/ AE	*S. aureus* (NCIMB 8625)	0.1	[80]
		B. subtilis (NCIMB 1026)	0.1	
		E. coli (B 81)	0.1	
		P. aeruginosa (NCIMB 1039)	0.1	
		(ATCC 13048) *E. aerogenes*	0.1	
H. ericoides	Methanol (100%)/ AE	*S. aureus* (NCIMB 8625)	0.1	
		B. subtilis (NCIMB 1026)	0.1	
		E. coli (B 81)	0.1	
		P. aeruginosa (NCIMB 1039)	0.1	
		(ATCC 13048) *E. aerogenes*	0.1	
H. xmoserianum	Methanol (100%)/ AE	*S. aureus* (NCIMB 8625)	0.1	
		B. subtilis (NCIMB 1026)	0.1	
		E. coli (B 81)	0.1	
		P. aeruginosa (NCIMB 1039)	0.1	
		(ATCC 13048) *E. aerogenes*	0.1	
H. olympicum	Methanol (100%)/ AE	*S. aureus* (NCIMB 8625)	0.025	
		B. subtilis (NCIMB 1026)	0.025	
		E. coli (B 81)	0.025	
		P. aeruginosa (NCIMB 1039)	0.05	
		(ATCC 13048) *E. aerogenes*	0.05	
H. scabrum	EO/ AE	*P. aeruginosa* (CIP 82118)	> 0.512	[81]
		S. aureus (ATCC 29213)	> 0.512	
H. lanceolatum	Methanol /LE	*K. pneumonia* (ATCC 13883)	0.064	[77]
		P. aeruginosa (ATCC 27853)	0.064	
		S. typhi (ATCC 6539)	0.032	
		E. faecalis (ATCC 10541)	0.064	
H. humifusum	Ethanol/ AE	*S. aureus* (ATCC 49444)	0.078	[16]
		L. monocytogenes (ATCC 19114)	0.078	
		B. cereus (ATCC 11778)	0.62	
		P. aeruginosa (ATCC 27853)	0.62	
		S. typhimurium (ATCC 14028)	1.25	
		E. coli (ATCC 25922)	0.62	
H.bupleuroides	Methanol/ LE	*B. subtilis* (ATCC 6633)	0.00156	[82]
		S. aureus (ATCC 25923)	0.00125	
		S. epidermidis (ATCC 12228)	0.0125	
		E. coli (ATCC 25922)	0.1	
	Methanol/ FL	*B. subtilis* (ATCC 6633)	0.0002	
		S. aureus (ATCC 25923)	0.025	
		S. epidermidis (ATCC 12228)	0.0125	
		E. coli (ATCC 25922)	0.1	
H. montbretii	Methanol/ LE	*B. subtilis* (ATCC 6633)	0.0002	
		S. epidermidis (ATCC 12228)	0.00625	
	Methanol ST	*B. subtilis* (ATCC 6633)	0.0002	
		E. coli (ATCC 25922)	0.1	
Hypericum capitatum var.	Petroleum ether/ WP	*S. pyogenes* (ATCC 19615)	2	[76]
		S. aureus (ATCC 25923)	-	

capitatum		*P. aeruginosa* (ATCC 27853)	2.2	
		E. coli (ATCC 25922)	-	
	Acetone/ WP	*S. pyogenes* (ATCC 19615)	0.28	
		S. aureus (ATCC 25923)	0.25	
		P. aeruginosa (ATCC 27853)	0.3	
		E. coli (ATCC 25922)	0.015	
	Methanol/ WP	*S. pyogenes* (ATCC19615)	0.25	
		S. aureus (ATCC 25923)	0.3	
		P. aeruginosa (ATCC 27853)	0.26	
		E. coli (ATCC 25922)	0.01	

AE: Aerial parts; ST: Stem; FL: flower; LE: leaf; WP: whole plant; *S. aureus: Staphylococcus aureus; S. epidermidis: Staphylococcus epidermidis; E. coli: Escherichia coli; P. aeruginosa: Pseudomonas aeruginosa; S. pyogenes: Streptococcus pyogenes; B. subtilis: Bacillus subtilis; B. cereus: Bacillus cereus; E. aerogenes*: *Enterobacter aerogenes; K. pneumonia: Klebsiella pneumonia; S. typhimurium: Salmonella typhimurium; S. typhi: Salmonella typhi; E. faecalis: Enterococcus faecalis; L. monocytogenes: Listeria monocytogenes.*

6. Antioxidant activity of *Hypericum* species

Oxidative stress is the main cause of many diseases such as atherosclerosis, arthritis, cancer, as well as neurodegenerative diseases [17]. Because some synthetic antioxidants such as BHA and BHT are now suspected of being harmful to human health [83], extensive research is being done to isolate phytochemicals that can act as antioxidants [17].

Many herbs usedin complementary medicine have antioxidant potential [84]. *Hypericum* species have been reported to contain many phenolic compounds and are good sources of antioxidants, making them possible to use in ethnomedicine [85].

The antioxidant capacity of *Hypericum* species has been well documented (Table 4). The antioxidant effect of the whole plant extracts of *H. capitatum* var. *capitatum* was tested. The results indicated that the methanolic and water extracts displayed moderate lipid peroxidation inhibitory effect in β-carotene bleaching test and strong inhibition in ABTS test. The methanolic extract also displayed stronger effect than α-Toc and BHT standards in DPPH test [76].

The antioxidant capacities of the methanolic extracts of three *Hypericum* species (*H. aviculariifolium, H. salsugineum, H. perforatum*) were evaluated. The methanolic extract of *H. salsugineum* showed the highest antioxidant effect (DPPH inhibition=88.29%) among the extracts [14].

The antioxidant effect of *H. scabrum* and *H. origanifolium* aerial parts extracts was tested. The species showed stronger activities in DPPH test than ascorbic acid and butylated hydroxytoluene standards [19].

When testing the antioxidant activity of any plant extract, one should take into account that this activity varies according to the plant part. Methanolic extracts of different plant parts of *H. hookerianum* (leaf, flower and aerial parts) were tested for antioxidant effect using different methods. The extract from leaf had the strongest antioxidant activity in comparison with the extracts from flowering tops and aerial parts [86].

Table 4. *Antioxidant activity of some Hypericum species*

Species	extract/ plant part	Technique	Concentration (mg/ml)	Results	Ref.
H. perforatum	Methanol (FL)	DPPH	-	scavenging %=32	[2]
H. perforatum	Methanol	DPPH	0.5	scavenging %=81.21 ±0.58	[14]
H. salsugineum	Methanol	DPPH	0.5	scavenging %=88.29 ±0.96	

H. aviculariifolium subsp. *depilatum* var. *depilatum*	Methanol	DPPH	0.5	scavenging % =86.88 ±0.87	
H. spectabile	Ethanol (AE)	DPPH	2	scavenging %=86.74	[84]
H. spectabile	Methanol (AE)	DPPH	-	mg/ml 0.028 0.567 ± EC50=	[87]
		FRAP	5	reducing power= 2.66 ± 0.031 mM Fe 2+	
H. pseudolaeve	Methanol (AE)	DPPH	-	0.036 mg/ml EC50=0.916 ±	
		FRAP	5	reducing power= 2.21 ± 0.015 mM Fe 2+	
H. thymbrifolium	Methanol (AE)	DPPH	-	EC50=0.622 ± 0.051 mg/ml	
		FRAP	5	0.036 reducing power= 2.58 ± mM Fe 2+	
H. neurocalycinum	Methanol (AE)	Anti-LPO	-	EC50= 2.49 ± 0.09 mg/ml	[87]
		DPPH	-	EC50= 0.251 ± 0.01 mg/ml	
		Superoxide anion	-	EC50= 0.613 ± 0.05 mg/ml	
		FRAP	5	FRAP value= 2.39 ± 0.039 mM Fe 2+	
H. malatyanum	Methanol (AE)	Anti-LPO	-	EC50= 4.82 ± 0.03 mg/ml	
		DPPH	-	EC50= 1.54 ± 0.04 mg/ml	
		Superoxide anion	-	EC50= 0.802 ± 0.03 mg/ml	
		FRAP	5	FRAP value= 2.23 ± 0.013 mM Fe 2+	
H. hookerianum	Methanol (LE)	ABTS	-	IC50= 5.60±0.30 µg/ml	[86]
		DPPH	-	IC50= 3.30±0.05 µg/ml	
		Hydrogen peroxide	-	IC50= 58.06±1.95 µg/ml	
		Lipid per oxidation	-	IC50= 58.00±1.42 µg/ml	
	Methanol (FLT)	ABTS	-	IC50= 7.65±0.26 µg/ml	
		DPPH	-	IC50= 5.10±0.12 µg/ml	
		Hydrogen peroxide	-	IC50=117.64±5.14 µg/ml	
		Lipid per oxidation	-	IC50= 295.00±11.2 µg/ml	
	Methanol (AE)	ABTS	-	IC50= 10.90±0.32	
		DPPH	-	IC50= 5.25±0.11 µg/ml	
		Hydrogen peroxide	-	IC50= 74.14±3.82 µg/ml	
		Lipid per oxidation	-	IC50= 850.00±28.4 µg/ml	
H. androsaemum	Methanol (AE)	DPPH	-	IC50= 92.70±2.85 µg/ml	[17]
		anion (super oxide)	0.5	Anion Scavenging%=33.20±1.22	
		anti-lipid peroxidation	0.5	Anti-lipid peroxidation%= 11.13±1.02	
H. androsaemum	Methanol (AE)	DPPH	-	IC50= 0.093 mg/ml	[80]
H. ericoides	Ethyl acetate (AE)	DPPH	-	IC50= 0.295 mg/ml	
H. x moserianum	Ethyl acetate	DPPH	-	IC50= 0.13 mg/ml	

	(AE)				
H. olympicum	Methanol (AE)	DPPH	-	IC50= 0.098 mg/ml	
H. origanifolium	Ethyl acetate (LE)	DPPH	-	IC50= 3.37 ± 0.26 µg/ml	[88]
H. origanifolium	Ethanol-water (AE)	DPPH	-	IC50= 3.79 ± 0.27 µg/ml	[19]
H. scabrum	Ethanol-water (AE)	DPPH	-	IC50= 3.65±0.40 µg/ml	
H. aucheri	Methanol (AE)	DPPH	0.01	scavenging %=58.2 ± 0.1	
		ABTS	0.01	scavenging %=65.6 ± 0.2	
H. barbatum	Methanol (AE)	DPPH	0.01	scavenging %= 31.9 ± 0.1	
		ABTS	0.01	scavenging %= 34.5 ± 0.2	
H. cerastoides	Methanol (AE)	DPPH	0.01	scavenging %=84.2 ± 0.3	
		ABTS	0.01	scavenging %=90.2 ± 0.1	
H. elegans	Methanol (AE)	DPPH	0.01	scavenging %=25.9 ± 0.1	
		ABTS	0.01	scavenging %=31.9 ± 0.2	
H. linarioides	Methanol (AE)	DPPH	0.01	scavenging %=54.2 ± 0.1	[6]
		ABTS	0.01	scavenging %=57.8 ± 0.4	
H. maculatum	Methanol (AE)	DPPH	0.01	scavenging %=56.2 ± 0.2	
		ABTS	0.01	scavenging %=61.9 ± 0.2	
H. richeri	Methanol (AE)	DPPH	0.01	scavenging %= 49.9 ± 0.1	
		ABTS	0.01	scavenging %=55.7 ± 0.2	
H. rumeliacum	Methanol (AE)	DPPH	0.01	scavenging %= 58.9 ± 0.2	
		ABTS	0.01	scavenging %=65.2 ± 0.1	
H. tetrapterum	Methanol (AE)	DPPH	0.01	scavenging %=61.8 ± 0.2	
		ABTS	0.01	scavenging activity%=68.3 ± 0.2	
H. umbellatum	Methanol (AE)	DPPH	0.01	scavenging activity%= 49.1 ± 0.2	
		ABTS	0.01	scavenging activity%=55.9 ± 0.2	
H. humifusum	Ethanol (AE)	DPPH	-	IC50=18.51 ± 4.94 µg/ml	[16]
H.bupleuroides	Methanol (LE)	DPPH	-	IC50=0.06 mg/ml	[82]
H. montbretii	Methanol (LE)			IC50=0.06 mg/ml	
H. capitatum var. *capitatum*	petroleum ether (WP)	Lipid peroxidation	-	IC50= >200 µg/ml	[76]
		DPPH	-	IC50= >200 µg/ml	
		ABTS	-	IC50= >200 µg/ml	
	acetone (WP)	Lipid peroxidation	-	IC50= >200 µg/ml	
		DPPH	-	IC50= >200 µg/ml	
		ABTS	-	IC50= 88.84 ± 1.40 µg/ml	
	methanol (WP)	Lipid peroxidation	-	IC50= 41.69 ± 1.29 µg/ml	
		DPPH	-	IC50= 16.82 ± 0.58 µg/ml	
		ABTS	-	IC50= 9.24 ± 0.28 µg/ml	
	water (WP)	Lipid peroxidation	-	IC50= 92.85 ± 1.05 µg/ml	
		DPPH	-	IC50= >200 µg/ml	
		ABTS	-	IC50=9.76 ± 0.14 µg/ml	

AE: Aerial parts; ST: Stem; FL: flower; LE: leaf; WP: whole plant; FLT: Flowering tops; Dw: dry weight

7. Conclusions

There are only few reports about the chemical composition of the genus *Hypericum*. In the current study, we compared the chemical composition of EOs isolated from different *Hypericum* species. This comparison can contribute to the addition of new criteria for chemotaxonomy to distinguish between *Hypericum* species. We have also reviewed several studies that included the isolation of chemical compounds from *Hypericum* species. We documented and classified about 100 different natural products isolated from *Hypericum* species. The isolated compounds are in the class of phenolic compounds, flavonoids and its glycosides, phloroglucinols, triterpenoid, benzophenones, naphthodianthrone and xanthones. Antibacterial and antioxidant activities of the genus have also been reviewed. There may be a need for other studies to accurately determine the components responsible for these biological activities, and to determine how to isolate and prepare them.

Declaration of competing interests

There is no conflict of interest.

Author contribution

The author was responsible for conception and design of the study, acquisition of data, analysis and interpretation of data, in addition to drafting and revising the manuscript and approving it for submission

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