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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 medicines. 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.
Keywords : Hypericum, Hypericaceae, chemical composition, antibacterial, antioxidant.
Running title :An Overview of Hypericum Species

INTRODUCTION

In developing countries, 70-95% of people depend on plants as their main method of treatment these days (Chassagne et al., 2021). According to the WHO, medicinal plants are the best source of medicines (Okmen and Balpınar, 2017). Some researchers believed that two-thirds of the world's plants are medically beneficial (Krishnaiah et al., 2011). Therefore, research on medicinal plants has increased rapidly in order to find new active substances that can be used in herbal medicine industries (Okmen and Balpınar, 2017).

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 diseases (Mimica-Dukića and Božin, 2007).

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 (Bhatt, Rawat, & Rawal, 2013). It has

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been reported that many phenolic compounds such as procyanidins, coumarins, flavonoids and tannins can scavenge radicals -in a dose-dependent manner- and are thus considered as therapeutic medicines for free radical diseases (Zheleva-Dimitrova et al., 2010).

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 (Vaou et al., 2021). These bioactive compounds are used as a starting point for the synthesis of antibiotics in order to treat infectious diseases (Kebede et al., 2021). In general, the extent of the antioxidant and antimicrobial effects of the extracts could be attributed to their phenolic compounds (Endes et al., 2015).

Hypericum is a large genus of flowering plants, including many species (Ion et al., 2022), 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 (Silva et al., 2021). Over the years, there has been a great interest in studying the different biological activities of Hypericum species (Ion et al., 2022). 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.

The genus Hypericum

Hypericaceae family contains shrubs or herbaceous plants. They have glandular hairs that contains essential oils (EOs) (Gedik, 2022). This family includes nine genera, one of which is Hypericum (Rojas et al., 2013). Hypericum contains nearly 500 species (Maltas et al., 2013), perennial, herbaceous, or scrubby plants (Bejaoui et al., 2017), widely distributed in mountainous, tropical and temperate regions (Toiu et al., 2016). The genus received a great as it is a source of a variety of compounds with various biological effects (Bejaoui et al., 2017).

Hypericum species are globally recognised for their significant ethno-medicinal properties, which are utilised in the treatment of various infections and diseases (Saddiqe et al., 2016). 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 (Rojas et al., 2013)".

Hypericum plants have been included in Pharmacopoeias of many countries such as Germany, Czechoslovakia, Russia, Romania, Poland and France (Rouis, 2011). Various products containing Hypericum plants or their extracts have been developed as additives and many brands such as beverages and yogurts include these plants (Rouis, 2011).

The biological effects of the plants depend on their contents of secondary metabolites (Seyrekoglua et al., 2022). The chemical content of Hypericum plants is diverse with xanthones, glycosides, pyrones, flavonoids, tannins, anthraquinones, lactones, lipids, phloroglucinols, coumarins and EOs (Demirci and Baser, 2006).

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 (Maltas et al., 2013).

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 (Caldeira et al., 2022). It is used as a mild antidepressant (Jaimand, 2013). 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 (Seyrekoglua et al., 2022).

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 (Balikci, 2020).

Hypericum plants are generally known to be poor in essential oil (generally oil yield <1%, w/w) (Rouis, 2011).

The essential oil (EO) composition of about 50 different Hypericum species have so far been identified (Özkan et al., 2013). 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.

Table 1. Chemical composition of Hypericum essential oils

Species	Plant part	Main compounds	Ref.
H. elegans	AE	g-gurjunene, aromadendrene, and undecane	(Anna et al., 2013)
H. tetrapterum	AE	Copaene, α -longipinene, cadinene	
H. hirsutum	AE	caryophyllene oxide, phytol, α -caryophyllene and undecane	
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	(Çakir et al., 1998)
H. scabroides	AE	hexadecanoic acid, spathulenol, nonacosane, dodecanoic acid, baeckeol and γ-muurolene	(Özkan Demirci et al., 2013)
H. kotschyanum	AE	α-pinene, nonacosane, hexadecanoic acid, β-pinene, spathulenol and limonene	
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	(Yüce-Babacan et al., 2017)

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H. lydium	AE	α-pinene, ß-pinene, ß-myrcene	
H. thymopsis	AE	α-pinene, spathulenol, limonene	(Koç and Arabaci, 2021)
H. perforatum	AE	(germacrene D); ((E)-caryophyllene); (2-methyloctane); (α-pinene) and (bicyclogermacrene)	(Đorđević, 2015)
H. perforatum	FL	(E- ß –farnesene); (n-hexadecanal); (E-nerolidol)	(Jaimand, et al., 2012)
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	
	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	(Sajjadi et al., 2015)
H. richeri	AE	germacrene D, bicyclogermacrene, α-pinene, ß-pinene, decanoic acid, ß -caryophyllene, δ-cadinene, spathulenol and tetracosane	(Jerkovića, et al., 2013)

H. patulum	AE	β-pinene, α-pinene, limonene and α-humulene	(Morshedloo et al., 2014)
H. laricifolium	AE	*α*-pinene, verticiol, 3-methyl-nonane, 2-methyl-octane and nonane	(Rojas et al., 2013)
H. rumeliacum	AE	undecane, dodecanal, and germacrene D	(Radulović and Blagojević, 2012)
H. rumeliacum	AE	(E)-β-ocimene, β-pinene, (Z)-β-ocimene, dodecanal, germacrene D, myrcene	(Djordjevic et al., 2020)
H. rumeliacum	AE	α-pinene, ß-pinene, dehydro-aromadendrene, α-copaene	(Couladis et al., 2003)
H. lydium	AE	*α* -pinene, β-pinene and β-myrcene	(Yüce-Babacan and Bagci, 2017)
H. ericoides	AE	n-nonane, n-undecane, α-cubebene, α-pinene	(Rouis, et al., 2011)
H. androsaemum	AE	longifolene, ß-gurjunene, and γ-gurjunene	(Jaimand, et al., 2013)
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)	(Khorshidi et al., 2020)
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)	(Bagci and Babacan, 2013)
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)	(Rouis, et al., 2011)
H. bupleuroides	AE	(β-sesquiphellandrene); (β-caryophyllene); (selina-3,7(11)-diene); (γ-elemene); (undecane); (germacrene-B)	(Demirci and Baser, 2006)
H. gaitii	AE	α-pinene, allo-aromadendrene, δ-cadinene, n-nonane, β-caryophyllene, α-selinene	(Grafakou et al., 2022)
H. mexicanum	AE	n-nonane, α-pinene	(Patiño-bayona et al., 2020)
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	(Senkal and Uskutoglu, 2020)
H. amblysepalum	AE	δ -3-carene, caryophyllene-oxide, cis-ocimene, ß-caryophyllene, α-pinene	(Babacan, 2019)
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)	(Demirci et al., 2005)
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	(Bagci and Babacan, 2011)
H.retusum	AE	α-pinene, limonene, spathulenol, β-pinene,	

		germacrene D	
H. maculatum	-	β-farnesene, n-undecane, β-caryophyllene, δ-cadinene, muurolene	(Gudžić et al., 2002)
H. foliosum	-	n-nonane, limonene, terpinolene, β–caryophyllene, β-pinene	(Santos et al., 1999)
H. brasiliense	WP	ß-Caryophyllene, α-Humulene, Caryophyllene oxide, Cubenol, aromadendrene	(Abreu et al., 2004)

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

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, environment, ontogeny, season, analytical method (Hajdari, et al., 2014), geographical distribution, type of glands and phenological cycle (Jerkovića et al., 2013).

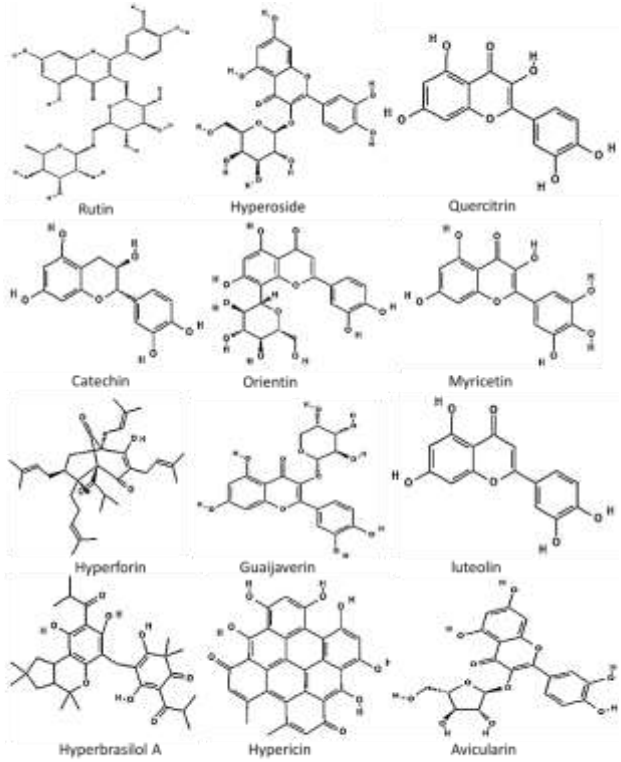

Figure 1: Chemical structure of some compounds isolated from *Hypericum* species

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 (Anna, Maria, Veaceslav, Ion, & Anatolie, 2013), 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 (Đorđević, 2015).

The variability of the EOs composition depend also on the part analyzed (Hajdari, et al., 2014). 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 -

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pinene and n-tetradecan were the main compounds of the flowers oil, where the leaves contained E-nerolidol, n-tetradecane and α -himachalene.

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.

Table 2. Compounds isolated from Hypericum species

Compound	Plant species	Plant part	Ref.
Phenolic compounds			
3-geranyl-1-(2'-methylbutanoyl) phloroglucinol	*H. scruglii*	AE	(Sanna et al., 2018)
	H. empetrifolium	FR	(Crockett et al.,
3-geranyl-1-(2'-methylpropanoyl) phloroglucinol	*H. scruglii*	AE	(Sanna et al., 2018)
	H. empetrifolium	FR	(Crockett et al., 2008)
3-(13-hydroxygeranyl)-1-(2'-methylbutanoyl) phloroglucinol	*H. scruglii*	AE	(Sanna et al., 2018)
adhyperfoliatin	*H. trichocaulon*	AE	(Daskalaki et al., 2022)
(E)-chlorogenic acid	*H. trichocaulon*	AE	
procyanidin A2	*H. trichocaulon*	AE	
Uliginosin B	*H. caprifoliatum*	AE	(Bridia et al., 2022)
	H. denudatum	AE	
	H. polyanthemum	AE	
Uliginosin A	*H. brasiliense*	LE - FL	(Rocha et al., 1995)
Isouliginosin B	*H. denudatum*	AE	(Bridia et al., 2022)
	H. polyanthemum	AE	
	H. brasiliense	LE - FL	(Rocha et al., 1995)
Hyperbrasilol B	*H. austrobrasiliense*	AE	(Bridia et al., 2022)
	H. caprifoliatum	AE	
	H. pedersenii	AE	
Hyperbrasilol B	*H. austrobrasiliense*	AE	(Bridi et al., 2022)
	H. caprifoliatum	AE	
	H. pedersenii	AE	
Hyperbrasilol A	*H. brasiliense*	LE - FL	(Rocha et al., 1995)
	H. denudatum	AE	(Bridi et al., 2022)
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	(Rocha et al., 1995)
hengshanoh A	*H. hengshanense*	AE	(Han et al., 2022)
Hyperforin	*H. perforatum*	-	(Cossuta et al., 2011)
	H. perforatum	FLS	(Tusevski et al., 2018)
	H. humifusum	AE	(Béjaoui et al., 2017)
	H. confertum	FL	(Camas et al., 2014)
	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	(Crockett et al., 2016)
hydroquinone	*H. lanceolatum*	STB	(Kenza et al., 2020)
3-O-Caffeoylquinic acid (chlorogenic acid)	*H. richeri*	AE	(Zdunica et al., 2017)
	H. perforatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	(Tusevski et al., 2018)
4-O-Caffeoylquinic acid	*H. barbatum*	AE	(Zdunica et al., 2017)
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	(Camas et al., 2014)
	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*	(Sanna et al., 2018)
Quinic acid	*H. perforatum*	FLS	(Tusevski et al., 2018)
3-p-Coumaroylquinic acid	*H. perforatum*	FLS	
3-Feruloylquinic acid	*H. perforatum*	FLS	
Flavonoids			
amentoflavone	*H. confertum*	LE- FL	(Camas et al., 2014)
	H. thymifolium	FL	
	H. linarioides	LE- FL	
	H. pruinatum	ST- LE- FL	
	H. olivieri	LE- FL	

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	H. scabrum	FL	
	H. lydium	LE- FL	
Rutin (quercetin 3-O-rutinoside)	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. triquetrifolium	AE	(Alzoubi et al., 2020)
	H. richeri	AE	(Zdunica et al., 2017)
	H. perforatum		
	H. hirsutum		
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	(Daskalaki et al., 2022)
	H. calycinum	-	(Kirmizibekmeza et al., 2009)
Hyperoside (quercetin 3-O-galactoside)	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. trichocaulon	AE	(Daskalaki et al., 2022)
	H. richeri	AE	(Zdunica et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. brasiliense	LE - FL	(Rocha et al., 1995)
	H. ternum	-	(Bernardi et al., 2007)
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	-	(Kirmizibekmeza et al., 2009)
Quercitrin (quercetin 3-O-rhamnoside)	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	(Zdunica et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. trichocaulon	AE	(Daskalaki et al., 2022)
	H. brasiliense	LE - FL	(Rocha et al., 1995)
	H. calycinum	-	(Kirmizibekmeza et al., 2009)
Isoquercitrin	*H. richeri*	AE	(Zdunica et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. ternum	-	(Bernardi et al., 2007)
	H. brasiliense	LE - FL	(Rocha et al., 1995)
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	-	(Kirmizibekmeza et al., 2009)
Quercetin	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. hyssopifolium	AE	(Cakir et al., 2003)
	H. confertum	ST- LE- FL	(Camas et al., 2014)
	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	(Zdunica et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. androsaemum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. brasiliense	LE – FL	(Rocha et al., 1995)
	H. laricifolium	AE	(Miguel et al., 2018)
	H. lanceolatum	FL	(Nguemo et al., 2020)
	H. coadunatum	AE	(Díaz, 2022)
	H. calycinum	-	(Kirmizibekmeza et al., 2009)
Quercetin 3-methyl ether	*H. ternum*	-	(Bernardi et al., 2007)
Quercetin 3,7-dimethyl ether	*H. ternum*	-	
Quercetin-3-O-α-l-arabinofuranoside	*H. hyssopifolium*	AE	(Cakir et al., 2003)
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	(Camas et al., 2014)
	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	(Tusevski et al., 2018)
	H. calycinum	-	(Kirmizibekmeza et al., 2009)
Epicatechin	*H. confertum*	ST- LE- FL	(Camas et al., 2014)
	H. thymifolium	ST- LE- FL	
	H. linarioides	ST- LE- FL	

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	H. pruinatum	ST- LE- FL	
	H. olivieri	ST- LE- FL	
	H. scabrum	ST- LE- FL	
	H. lydium	ST- LE- FL	
	H. calycinum	-	(Kırmızıbekmez et al., 2009)
	H. perforatum	FLS	(Tusevski et al., 2018)
Amentoflavone	*H. perforatum*	FLS	
	H. confertum	LE- FL	(Camas et al., 2014)
Cyanidin 3-O-glycoside	*H. perforatum*	FLS	(Tusevski et al., 2018)
Cyanidin 3-O-rhamnoside	*H. perforatum*	FLS	
miquelianin	*H. calycinum*	-	(Kırmızıbekmez et al., 2009)
myricitrin	*H. trichocaulon*	AE	(Daskalaki et al., 2022)
myricetin	*H. lanceolatum*	FL	(Nguemo et al., 2020)
orientin	*H. coadunatum*	AE	(Diaz, 2022)
	H. hirsutum	AE	(Zdunić et al., 2017)
2''-O-Acetyl-orientin	*H. hirsutum*	AE	
I3–II8 Biapigenin	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. richeri	AE	(Zdunić et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. lanceolatum	FL	(Nguemo et al., 2020)
	H. hyssopifolium	AE	(Cakir et al., 2003)
	H. trichocaulon	AE	(Daskalaki et al., 2022)
	H. ternum	-	(Bernardi et al., 2007)
	H. calycinum	-	(Kırmızıbekmez et al., 2009)
Myricetin 3-O-rutinoside	*H. richeri*	AE	(Zdunić et al., 2017)
Myricetin 3-O-galactoside	*H. richeri*	AE	
Myricetin 3-O-glucoside	*H. richeri*	AE	
luteolin	*H. brasiliense*	LE - FL	(Rocha et al., 1995)
Kaempferol 3-O-rutinoside	*H. perforatum*	FLS	(Tusevski et al., 2018)
kaempferol-3-O-β-D-glucopyranoside	*H. lanceolatum*	FL	(Nguemo et al., 2020)
kaempferol	*H. brasiliense*	LE - FL	(Rocha et al., 1995)
friedelanone	*H. lanceolatum*	FL	(Nguemo et al., 2020)
friedelan-3-β-ol	*H. lanceolatum*	FL	
B-type procyanidin dimer	*H. perforatum*	FLS	(Tusevski et al., 2018)
	H. perforatum	FLS	
	H. perforatum	FLS	
Procyanidin trimer	*H. perforatum*	FLS	
8-C- β-L- arabinopyranosylapigenin	*H. coadunatum*	AE	(Diaz, 2022)
guaijaverin	*H. coadunatum*	AE	
	H. ternum	-	(Bernardi et al., 2007)
	H. brasiliense	LE - FL	(Rocha et al., 1995)
Hevetrichoside C	*H. coadunatum*	AE	(Diaz, 2022)
Naphthodianthrone			
Hypericin	*H. triquetrifolium*	AE	(Alzoubi et al., 2020)
	H. perforatum	FLS	(Tusevski et al., 2018)
	H. perforatum	-	(Cossuta et al., 2011)
	H. humifusum	AE	(Béjaoui et al., 2017)
	H. confertum	LE- FL	(Camas et al., 2014)
	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	(Zdunić et al., 2017)
	H. perforatum	AE	
	H. barbatum	AE	
	H. hirsutum	AE	
	H. acutum	AE	
	H. maculatum	AE	
	H. hyssopifolium	AE	(Cakir et al., 2003)
Protopseudohypericin	*H. perforatum*	FLS	(Tusevski et al., 2018)
Pseudohypericin	*H. perforatum*	FLS	
	H. confertum	LE- FL	(Camas et al., 2014)
	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	(Zdunić et al., 2017)
	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	(Crockett et al., 2016)
2-benzoyl-3,3-dimethyl-4S,6R-bis-(3-methylbut-2-enyl)-cyclohexanone	*H. galioides*	AE	
betulinic acid	*H. lanceolatum*	STB	(Zofou et al., 2011)
	H. lanceolatum	STB - TW	(Happi et al., 2023)
ursolic acid	*H. lanceolatum*	STB - TW	
Benzophenones			
2,2',5,6'-tetrahydroxybenzophenone	*H. lanceolatum*	STB	(Zofou et al., 2011)
isogarcinol	*H. lanceolatum*	FL	(Nguemo et al., 2020)
Hyperibone	*H. coadunatum*	AE	(Diaz, 2022)
Xanthone			
5-hydroxy-3-methoxyxanthone	*H. lanceolatum*	STB	(Zofou et al., 2011)
6,7-dihydroxy-1,3-dimethoxyxanthone	*H. lanceolatum*	STB	(Kowa et al., 2020)
1,3,5,6-tetrahydroxy-4-prenylxanthone	*H. lanceolatum*	STB	
3-hydroxy-5-methoxyxanthone	*H. lanceolatum*	STB	(Zofou et al., 2011)
	H. lanceolatum	STB	(Kowa et al., 2020)
1,6-dihydroxyxanthone	*H. lanceolatum*	STB - TW	(Happi et al., 2023)
euxanthone	*H. lanceolatum*	FL	(Nguemo et al., 2020)
norathyriol	*H. lanceolatum*	STB - TW	(Happi et al., 2023)
1,7-dihydroxyxanthone	*H. laricifolium*	AE	(Miguel et al., 2018)
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	(Ramírez-gonzález et al., 2013)
2,8-dihydroxy-1-methoxyxanthone	*H. laricifolium*	AE	(Miguel et al., 2018)
3,8-dihydroxy-1,2-dimethoxyxanthone	*H. laricifolium*	AE	
1-hydroxy-7-methoxyxanthone	*H. laricifolium*	AE	(Ramírez-gonzález et al., 2013)
2-hydroxy-xanthone	*H. laricifolium*	AE	

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6-deoxyisojacareubin	*H. lariciifolium*	AE	
1,3,6-trihydroxy-7-methoxy-xanthone	*H. lariciifolium*	AE	
Hyperixanthone A	*H. trichocaulon*	AE	(Daskalaki et al., 2022)
5-O-methyl-2-deprenylrheediaxanthone B	*H. roeperianum*	RO	(Rath et al., 1996)
5-O-methylisojacareubin	*H. roeperianum*	RO	
5-O-demethylpaxanthonin	*H. roeperianum*	RO	
roeperanone	*H. roeperianum*	RO	
Dimethylmangiferin	*H. perforatum*	FLS	(Tusevski et al., 2018)
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

According to this survey, quercetin, 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.

Antimicrobial activity of Hypericum species

Microorganisms are widespread in nature and are beneficial to life, but some can cause serious harm (Maraz and Khan, 2021). Microorganisms can easily access food (Gonelimali, 2018). Currently, drug-resistant bacteria are rapidly emerging all over the world and pose a threat to the efficiency of antibiotics (Özkan et al., 2019). Along 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 (Anusha et al., 2015). The genus Hypericum has been found to produce compounds that have antimicrobial properties (Bejaoui et al., 2017). Many studies have been conducted in many countries showing the antibacterial effect of this genus (table 3).

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 (Selvamohan et al., 2012). 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	(Özkan et al., 2019)
		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/ AE	*B. cereus* (human isolate)	0.0075	(Grafakou et al., 2020)
		S. aureus (ATCC 11632)	0.015	
		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. jovis	EO/ AE	*B. cereus* (human isolate)	0.0075	(Grafakou et al., 2020)
		S. aureus (ATCC 11632)	0.015	
		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	(Saddiqe et al., 2020)
		B. subtilis (NCIMB 1026)	0.1	
		E. coli (B 81)	0.1	
		P. aeruginosa (NCIMB 1039)	0.1	
		E. aerogenes (ATCC 13048)	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	
		E. aerogenes (ATCC 13048)	0.1	
H. uniconianum	Methanol(100%)/	*S. aureus* (NCIMB 8625)	0.1	

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H. humifusum	Ethanol/ AE	*S. aureus* (ATCC 49444)	0.078	(Toiu et al., 2016)
		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	(Ceylan et al., 2020)
		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. capitatum	Petroleum ether/ WP	*S. pyogenes* (ATCC 19615)	2	(Boga et al., 2016)
		S. aureus (ATCC 25923)	-	
		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)	0.02	

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.*

Antioxidant activity of Hypericum species

Oxidative stress is the main cause of many diseases such as atherosclerosis, arthritis, cancer, as well as neurodegenerative diseases (Saddiqeet al., 2016).

Because some synthetic antioxidants such as BHA and BHT are now suspected of being harmful to human health (El Ouariachi et al., 2014), extensive research is being done to isolate phytochemicals that can act as antioxidants (Saddiqe et al., 2016). Many herbs used in complementary medicine have antioxidant potential (Mohammed et al., 2020). Hypericum species have been reported to contain many phenolic compounds and are good sources of antioxidants, making them possible to use in ethnomedicine (Ozkana et al., 2018).

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 (Boga et al., 2016).

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 (Maltas et al., 2013).

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 (Seyrekoglua et al., 2022).

It is important to consider that the antioxidant activity of a plant extract can differ depending on the specific part of the plant being tested. 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 (Chandrashekhara et al., 2009).

Table 4. Antioxidant activity of some Hypericum species

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Species	extract/ plant part	Technique	Concentration (mg/ml)	Results	Ref.
H. perforatum	Methanol (FL)	DPPH	-	scavenging %=32	(Okmen and Balpinar, 2017)
H. perforatum	Methanol	DPPH	0.5	scavenging %=81.21 ±0.38	(Maltas et al., 2013)
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	(Mohammed et al., 2020)
H. spectabile	Methanol (AE)	DPPH	-	EC50= 0.567 ± 0.028 mg/ml	(Ozkan et al., 2018)
		FRAP	-	reducing power= 2.66 ± 0.031 mM Fe 2+	
H. pseudolaeve	Methanol (AE)	DPPH	-	EC50=0.916 ± 0.036 mg/ml	
		FRAP	3	reducing power= 2.21 ± 0.015 mM Fe 2+	
H. thymbrifolium	Methanol (AE)	DPPH	-	EC50=0.622 ± 0.051 mg/ml	
		FRAP	3	reducing power= 2.58 ± 0.036 mM Fe 2+	
H. neurocalycinum	Methanol (AE)	Anti-LPO	-	EC50= 2.49 ± 0.09 mg/ml	(Ozkan et al., 2018)
		DPPH	-	EC50= 0.251 ± 0.03 mg/ml	
		Superoxide anion	-	EC50= 0.613 ± 0.05 mg/ml	
		FRAP	3	FRAP value= 2.38 ± 0.039 mM Fe 2+	
H. malatyanum	Methanol (AE)	Anti-LPO	-	EC50= 4.82 ± 0.03 mg/ml	
		DPPH	-	EC50= 1.34 ± 0.04 mg/ml	
		Superoxide anion	-	EC50= 0.802 ± 0.03 mg/ml	
		FRAP	3	FRAP value= 2.23 ± 0.013 mM Fe 2+	
H. hookerianum	Methanol (LE)	ABTS	-	IC50= 5.60±0.30 µg/ml	(Chandrashekhar et al., 2009)
		DPPH	-	IC50= 3.30±0.03 µg/ml	
		Hydrogen peroxide	-	IC50= 58.06±1.93 µg/ml	
		Lipid per oxidation	-	IC50= 58.00±1.42 µg/ml	
	Methanol (FLT)	ABTS	-	IC50= 7.65±0.26 µg/ml	
		DPPH	-	IC50= 3.10±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= 830.00±28.4 µg/ml	
H. androsaemum	Methanol (AE)	DPPH	-	IC50= 92.70±2.85 µg/ml	(Saddiqe et al., 2016)
		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	(Saddiqe et al., 2020)
H. ericoides	Ethyl acetate (AE)	DPPH	-	IC50= 0.293 mg/ml	
H. x moserianum	Ethyl acetate (AE)	DPPH	-	IC50= 0.13 mg/ml	
H. olympicum	Methanol (AE)	DPPH	-	IC50= 0.098 mg/ml	
H. origanifolium	Ethyl acetate (LE)	DPPH	-	IC50= 3.37 ± 0.26 µg/ml	(Ozturk et al., 2009)
H. origanifolium	Ethanol-water (AE)	DPPH	-	IC50= 3.79 ± 0.27 µg/ml	([illegible] et al., 2022)
H. scabrum	Ethanol-water (AE)	DPPH	-	IC50= 3.63±0.40 µg/ml	
H. aucheri	Methanol (AE)	DPPH	0.01	scavenging %=58.2 ± 0.1	(Zheleva-Dimitrova et al., 2010)
		ABTS	0.01	scavenging %=63.6 ± 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 %=33.9 ± 0.2	
H. linarioides	Methanol (AE)	DPPH	0.01	scavenging %=34.2 ± 0.1	
		ABTS	0.01	scavenging %=57.8 ± 0.4	
H. maculatum	Methanol (AE)	DPPH	0.01	scavenging %=56.2 ± 0.2	
		ABTS	0.01	scavenging %=83.0 ± 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 %= 38.9 ± 0.2	
		ABTS	0.01	scavenging %=65.2 ± 0.1	
H. tetrapterum	Methanol (AE)	DPPH	0.01	scavenging %=63.8 ± 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	(Tuna et al., 2016)
H. bupleuroides	Methanol (LE)	DPPH	-	IC50=0.06 mg/ml	(Ceylan et al., 2020)
H. montbretii	Methanol (LE)			IC50=0.06 mg/ml	
H. capitatum var. *capitatum*	petroleum ether (WP)	Lipid peroxidation	-	IC50= >200 µg/ml	(Boga et al., 2016)
		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= 41.09 ± 1.29 µg/ml	
		DPPH	-	IC50= 16.82 ± 0.38 µg/ml	
		ABTS	-	IC50= 9.24 ± 0.28 µg/ml	
	water (WP)	Lipid peroxidation	-	IC50= 92.83 ± 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

CONCLUSION

There are only few reports about the chemical composition of the genus Hypericum. In the current review, the chemical composition of the essential oils isolated from different Hypericum species was compared, which may contribute to adding new criteria for chemotaxonomy of these species. In addition, about 100 different natural products isolated from Hypericum species were documented and classified, and these compounds were found to be 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.

Conflict of Interest

There is no conflict of interest.

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التركيب الكيميائي، وبعض الفعاليات الحيوية لجنس Hypericum

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*دكتوراه في علم الحياة النباتية، محاضر في كلية الزراعة، جامعة حلب، ** دكتوراه في هندسة التقانات الحيوية، مدرس في كلية الهندسة التقنية، جامعة حلب

النباتات الطبية هي أفضل مصدر للأدوية، لذلك زادت الدراسات على هذه النباتات بهدف البحث عن مواد فعالة جديدة يمكن استخدامها في الصناعات الدوائية العشبية. الجنس Hypericum هو جنس كبير من النباتات الزهرية، ويضم العديد من الأنواع المنتشرة عالمياً، تعتمد أهمية أنواع الجنس بشكل أساسي على وجود مستقلبات ثانوية تبدي خصائصاً صيدلانية وتجميلية. تشتهر أنواع الجنس Hypericum في جميع أنحاء العالم بأهميتها الطبية وتستخدم لعلاج الالتهابات والأمراض، كعوامل مدرة للبول، ومدرة للصفراء، ومضادات التشنج، ومضادات الصرع، وكذلك للروماتيزم ، والألم العصبي، والطفيليات، وعسر الهضم، والإسهال، وما إلى ذلك.يوجد فقط تقارير قليلة عن التركيب الكيميائي لأنواع جنس Hypericum. تهدف الدراسة الحالية إلى تقديم لمحة عامة عن أهمية جنس Hypericum ، ملخص عن التركيب الكيميائي، وكذلك الفعاليات المضادة للبكتيريا والمضادة للأكسدة لأنواع مختلفة من الجنس.

الكلمات المفتاحية: *Hypericum*، Hypericaceae، التركيب الكيميائي، مضاد جرثومي، مضاد أكسدة.