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REVIEW ARTICLE

A Review of Botany and Pharmacological Effect and Chemical Composition of *Echinophora* Species Growing in Iran

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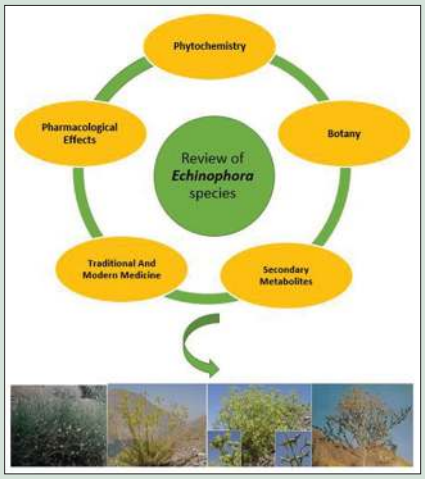
ABSTRACT

This review was conducted to investigate the botany, phytochemistry, and pharmacological properties of *Echinophora* species. The information of this review was obtained by searching for keywords *Apiaceae*, *Echinophora*, pharmacological effects, and traditional and modern medicine in scientific articles and books published in search engines Scopus, Google Scholar, Science Direct, PubMed, and Web of Science. The traditional uses of *Echinophora* and the existence of valuable phytochemicals in the plant have led to isolation and drug discovery of natural medicines such as antibiotic, analgesics, and anticancer drugs, and the beneficial effects of these plants can widely be used in healthcare.

Key words: Botany, chemical composition, *Echinophora*, modern medicine, traditional medicine

SUMMARY

- *Echinophora* species are medicinal and aromatic plants that are belong to Apiaceae family. This genus have four species in Iran. The botany, geographical distribution, traditional and pharmacological effects of *Echinophora* genus were described. Also, the major chemical constituents of the essential oil and extract of different species of *Echinophora* that have been reported. Overall, the existence of valuable phytochemicals purpose *Echinophora* species as novel candidate to isolation and drug discovery of natural medicines such as antibiotic, analgesics, and anticancer drugs.



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INTRODUCTION

Using medicinal plants to treat coincides with a human life history. Natural remedies, especially herbal drugs, have been considered as the basis and even in some cases the only method of treatment.[1] The use of this treatment method has a history of all civilizations and is an important component in the development of common medical science. Although, in the past half century, the use of chemical and synthetic drugs has become extremely popular, their side effects made re-orientation to medicinal plants. It is well known that the uses of medicinal plants have been historically one of the effective treatment methods. Although plants have always been and are regarded as a valuable resource for humans, enough scientific investigations have not been done on them, and there are still largely unknown plants in the world. Consequently, there are thousands of new unknown compounds in nature that can be used not only as drugs but also as a leader to make other synthetic drugs.[2,3] One of these plants is *Echinophora* on which there are some studies with promising results in the literature for treatment of various diseases. This study aimed to review the botanical, phytochemistry, and pharmacology properties of steel *Echinophora* species in Iran.

Echinophora genus belongs to *Umbelliferae* or *Apiaceae*, and in Persian, it is known with the names *Khosharizeh*, *Khosharuzeh*, or *Tighe Turagh*. It is an aromatic plant with a pleasant flavor, which, in addition to its numerous food consumption, has medicinal uses.[4,5]

Echinophora genus has several species including *Echinophora carvifolia* Boiss. and Balansa, *Echinophora chrysantha* Freyn and Sint, *Echinophora lamondiana* Yildiz and Z. Bahcecioglu, *Echinophora scabra* Gilli, *Echinophora spinosa* L., *Echinophora tenuifolia* L.,

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Echinophora trichophylla Sm., *Echinophora tournefortii* Jaub. and Spach, *E. tenuifolia subsp. sibthorpiana* (Guss.) Tutin or *Echinophora sibthorpiana* Guss., and *Echinophora orientalis* Hedege and Lamond in the world.[6] In Iran, there are four species that mostly grow in the mountains of Zagros, Alborz, and Azerbaijan. The scientific name of these species are *E. platyloba* DC. called Prickly parsnip, *E. cinerea* (Boiss) Hedge & Lamond called Forage Prickly parsnip, Mountain Prickly parsnip and Fedale, *E. orientalis* Hedge & Lamond called Narrow Leaves Prickly parsnip and East Prickly parsnip, *E. sibthorpiana* Guss. called Aromatic Prickly parsnip.[7]

BOTANY

The botany of *Umbelliferae* or *Apiaceae* family

Umbelliferae or *Apiaceae* species have a very uniform morphology characteristics and traits that are very privileged and exclusive.[8] In recognition of genus and species of this family, the structure of fruit and base leaves of the plant, inflorescence, as well as the type of simple or compound umbel is important. All parts of the plants of this family have secretory apparatus. This family which has 275 genera and 2850 species generally grow in temperate regions of both Northern and Southern hemispheres.[9] *Umbelliferae* herbs are generally herbaceous of life of a year or several years and have almost right or creeping stems and are usually striate.[10] The central part of the stem is hollow due to loss of brain cells and changes to empty-pipe or overall ducts.[11] *Umbelliferae* name has been gotten from the arrangement of the flowers held in umbrella-like (*Umbelle*) bunches. The flowers are single, usually small, sepals are usually white, rarely pink and have five petals.[12] The fruits of the members of this family are dry consisting of one or two bayonets to back and side as a nonflourished cylinder separated by a wide or narrow screen and have no fluff or covered with them filled with scales or thorns.[13] Among *Umbelliferae* species, there are various species often recognized by people and used in medicine.[10]

Botany of *Echinophora* genus

Echinophora genus has four species in Iran. Two species *E. platyloba* and *E. cinerea* are specific to Iran and two other species, namely *E. sibthorpiana* and *E. orientalis*, grow in Anatolia, Armenia, Russia, Turkmenistan, Afghanistan, Peninsula Balkans, Crete, Cyprus, and Syria, in addition to Iran.[14]

Botany of *Echinophora platyloba*

This plant has the following characteristics: a steady base, slightly covered with pollen and downy, matte green or yellowish opaque, tough and thorny with single stems, branched from bottom, with grooved branches, yellowish or bluish-green, thick, sturdy and stiff, highly branched, with tentacles distorted, radical broad leaves with long with shoulder division with 3–5 pairs of wide-angle divisions, cornered, ovate more or less with 3–4 depth parts with 2–3 divisions thorn at the end, with separated tops, and reduced linear leaflets thorn at the end fully or triangular with yellowish flowers with collected yellow in small circles with 2–5 small rays very short or equal, bracts of triangular faces-bayonets, approximately the same, sharp, in collars almost returned, the bowl has five sharp teeth and male flowers with different heights, triangular and long folding petals slightly downy, almost not equal in height, broad elongated pear-shaped fruit with no blades or sideways, creamy cone, and complete base, with membrane, take away; flowering time is May and June.[15]

Botany of *Echinophora sibthorpiana*

It is a perennial or biennial plant, with a height of 20–50 cm, fluffy short shaggy slept together, having relatively thick, hard, single, and grooved stems. It has often large ramifications, corymb-shaped, leaves with bases of the dimensions 3.5–22 cm × 12–40 cm with the broad triangular or oval area, with three times shoulders deep divisions, with triangular-wide long-term parts and also from base to middle divided twice to 5–7 linear narrow passage, with white tips at the end, stem leaves with deep shoulder divisions, with nondivided parts or with 2–3 teeth and pale yellow flowers, with downy petals, nonradial, integrated in multiple umbrellas with 2–3[5] short beam, with 2–10 mm length, not equal height, bracts of short collar, bayonet, the triangular bayonet of the bracts, hard, long and wide pyramidal fruit, no rag or blade, umbelet of fruit-bearing 8 mm diameter, more or less ovate; flowering time is June to July.[16]

Botany of *Echinophora orientalis*

It is a perennial plant, dense and bushy, slightly downy, green, standing, highly branched, with height of 30–100 cm, with numerous stems, standing or crouching-wide, with thin branches, almost point-guard and leading up to the inflorescence umbrellas, lower leaves being large, with dimensions of 8–15 cm × 25–40 cm wide, ovate to long-term, 2–3 times deep shoulder divisions with 2–5 pairs of linear segments and cotton, with a length of 1–14 cm, very small and often simple stems, with white, small, radial flowers, integrated with the umbrella inflorescence peduncle length 3 (5.1)–10 (22) cm, bracts of 5–8 number of extents, a linear-bayonet, returned down, with the length of 5–30 mm, of the same heights or not, rays of 7 (5)–15, with a length of 5–30 mm wide at the base widened upward, a subsidiary of bract of the neck six triangular-bayonet shaped, with a length of 4–6 mm, unequal height, returned down, hard and thorns and stinging, minor pedicle 15, outer ones longer than from the bowl and the outer umbrella petals with the length of 2.5–3.5 mm, umbrella fruit as big as 5–10 mm × 8–15 mm, almost flat stretch, nut fruit leading to the creamy of 3–5 mm and the flowering period June to July.[17]

Botany of *Echinophora cinerea*

It is a perennial plant, with a height of 12–40 cm, slightly downy, with standing, thick, grooved stems, connected to panicle of short branches, base leaves with the size of 1.5–15 cm × 9–40 cm triangular to wide long, with 3–4 times deeper shoulder ramifications, covered with shaggy, long, wide divisions and subdivisions with solid, linear, narrow, short, studs, at the length of 5 mm, stem smaller and eroded, yellow flowers, inflorescence including lots of umbrella with 5–7 nonequal rays in height a length of 5–10 mm, bracteole of oval face, returned and with different heights, with dimensions of 1–2 cm × 3–4 mm, bracteole of umbelet of five, ovate and nonequal height at dimensions 1.5–3 mm × 1.5–4 mm, 10–13 peduncle of umbelet at the length of 0–4 mm, outer flowers with highlighted foot cream umbelet, with bowel ovate divisions, petals are small and shaggy rag or hairy, downy fruits, with a length of 3–3.5 mm, and flowering time is July to August[18] [Figure 1].

THE GEOGRAPHICAL DISTRIBUTION OF *ECHINOPHORA* GENUS IN IRAN

E. platyloba species has geographical distribution in Alborz: Damavand, Ab Ali, West: Arak, Mahallat between Bagher Abad and Chehel Cheshmeh, Tangeh Badam, Bakhtaran, Fars: Servant, Kherameh, Deh Sheikh, East: Torbat-e Heydarieh, Robat Sefid and Neyshabur, Chaharmahal va Bakhtiari: Tange Sayad protected area, Ardal, Plain Dinarun, Shahr-e kord, Sureshjan, and from Harouni to Karsang.[15,19]

E. sibthorpiana is found in the North: Qazvin, Akbarabad, Gilan: Rostam Abad near Rasht, West: Bisheh, Northeast: between Bojnoord and Maravetappe, Alborz area: between Tehran and Ab Ali, Evin,

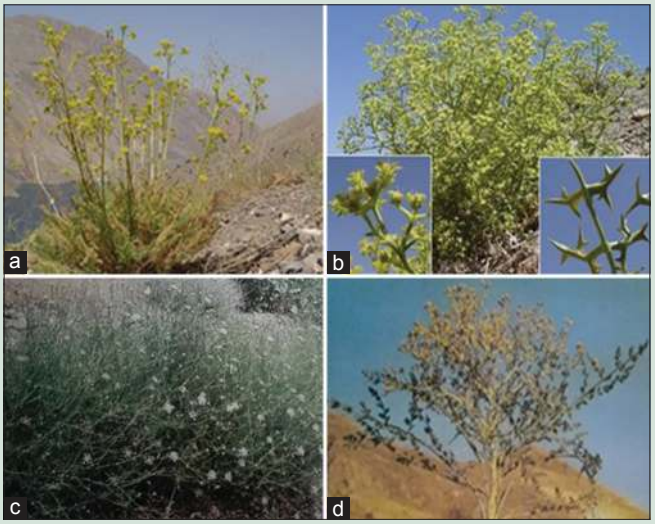

Figure 1: (a) *E. cinerea* (Boiss.) Hedge and Lamond (picture of author), (b) *E. platyloba* DC (picture of author), (c) *E. orientalis* Hedge and Lamond (35), (d) *E. sibthorpiana* Guss (36)

Roodehen, between Tehran and Jajrood, Pachenar near Qazvin, Manjil, Ali Abad near Karaj, Halgheh Heights near Mardabad-Karaj, Central District: Ghamsar Kashan.[16]

E. orientalis has geographical distribution in the Northwest: Azerbaijan, Tabriz, Talkheh Rood Valley, Khanian, Garadagh, Darreh Diz, Julfa, Marand toward Jolfa, Darreh Ghatour, Maku toward Khoy, Asalem, and Miyaneh.[17]

E. cinerea exclusively grows in the Central Zagros Mountains in the Province of Lorestan and Chaharmahal va Bakhtiari.[7] In Bakhtiari, it grows in Se Gaveh Tangeh Mahmoud, Tangeh Nagou, Sefid Dasht, Sefid Kouh, Fars, Mount Dena, Sabzkouh: Darreh Bazoft, Mount Kino, near Lebed: Naghan and Chahartagh.[18,19]

BIOLOGICAL EFFECTS OF *ECHINOPHORA* GENUS

Traditional medicine

Echinophora genus is used in traditional medicine to strengthen the stomach. This plant with the local name *Fedaleh* is used as a seasoning in food, and local people use this in pickle and tomato sauce as preservatives, antifungal, and antimicrobial.[4,5]

E. platyloba with the name *Prickly parsnip* is known as an aromatic plant in food among the people of Iran and is used to flavor buttermilk and yogurt.[7]

In the support of this traditional use, Zarali *et al*. studied the effects of adding the extract of *Echinophora* on the quality and sensory properties of buttermilk. The results showed that adding the extracts of *E. platyloba* in addition to improving the taste of the samples was useful in inhibiting the growth of mold and yeast in buttermilk samples. Thus, the extract of this plant can be used as the natural flavors of herbs and spices in buttermilk as a dairy drink.[20] Ehsani *et al*. studied the effects of adding the essential oil of *E. platyloba* on pasteurized creams and analyzed for microbial characteristics, sensorial properties, and lipid stability. Based on the results of study, application of *E. platyloba* essential oil as natural preservatives is especially recommended in high fat dairy products such as butter and cream.[21] Hasanvand *et al*. studied inhibitory effect of *E. platyloba* essential oil on *Aspergillus flavus* in cheese. Results indicated that essential oil of *E. platyloba* had antifungal activity and can be used as a mold inhibitor in foods such as cheese.[22]

Modern medicine

Pharmacological effects of Echinophora Cinerea

Antioxidant effects[23,24] and antibacterial activity related to essential oil of this species on the bacteria *Staphylococcus aureus*, *Escherichia coli*, *Staphylococcus*-resistant methicillin-resistant *S. aureus*, *Bacillus cereus*, *Shigella dysenteriae*, and *Listeria monocytogenes* and antifungal activity of essential oil on *Candida albicans* have been reported.[5,23,24] Several studies have been reported anticancer effect of *E. cinerea* extract on bladder cell carcinoma, leukemia cell, and Jurkat cells.[25,26]

Pharmacological effects of Echinophora sibthorpiana

The pharmacological activities of this species have not been reported by Iranian researchers so far.

Pharmacological effects of Echinophora orientalis

The antioxidant properties of essential oil of leaves, roots, and grains of this species have been reviewed, where the highest antioxidant activity is related to the root of this plant.[27]

Pharmacological effects of Echinophora platyloba

The antioxidant activity of the extract[28,29] and essential oil[28,30-32] and antibacterial property of the extract on *Alcaligenes faecalis*, *Serratia marcescens*, *Providencia rettgeri*, *L. monocytogenes*, *S. aureus*, *Salmonella enteritidis*, *Salmonella typhimurium*, *Salmonella choleraesuis*, *Pseudomonas aeruginosa*, *Nocardia asteroides*, and *nocardia brasiliensis*[29,33-36] and the antibacterial properties of essential oils on bacteria *S. aureus* and *L. monocytogenes*, *E. coli*, *Bacillus subtilis*, *Aspergillus niger*, *Bacillus cereus*, *S. typhimurium*, *P. aeruginosa* have been reported.[31,35,37-39] Antifungal properties of the extract on *C. albicans*, *Aspergillus flavus*, and *Penicillium expansum* have been proven. Moreover, antifungal properties effects of this extract at a concentration of 250 mg against dermatophytes *Trichophyton verrucosum* and *Trichophyton schoenleinii* is desirable and *Trichophyton mentagrophytes*, *Microsporum canis*, and *Epidermophyton floccosum* depending on the circumstances and how serious the infection is are usable,[40-48] and antifungal effects essence of the extract of this species on the fungus *Candida tropicalis*, *Robrardoterolla*, *Rhodotorula mucilaginosa*, *C. albicans*, *Fusarium graminearum*,[49,50] and anticancer, antimutation, and apoptosis related to the extract on cancer cells of blood, lung, and prostate have been reported.[51-53] The effects of the extract on premenstrual syndrome (dysmenorrhea),[54-59] effects of the extract on reducing blood fat, liver, kidney protection, increasing the secretion of testosterone, and strengthening sexual activity, effective on pituitary-thyroid axis hormones,[60-62] central and peripheral analgesic effect of the extract,[63] healer's effect on wound healing,[64] and insecticidal properties of essential oil on *Tribolium castaneum* (*Herbst*), *Callosobruchus maculatus*, and *Rhyzopertha dominica*[65] have been established. Acute and chronic toxicity effects of the extract have been investigated by Mirghazanfari *et al*., where the results show that *Echinophora* extract at a dose of 50–200 mg/kg is safe and a dose of 500 mg/kg of Wistar rats body weight is toxic.[4] Finally, studying the extracts and essential oil of this plant showed that the extract has antispasmodic effect to stimulate muscle contraction and bowel.[66]

SECONDARY METABOLITES OF *ECHINOPHORA* GENUS

Essential oil

The major chemical constituents of the essential oil of different species of *Echinophora* that have been identified are shown in Table 1. This table

Table 1: Reported major constituents of *Echinophora* genus essential oil from Iran

Major essential oil constituents					Species of *Echinophora L.*	Plants collect regional	References
Carvacrol (3.79%)	α-pinene (9.79%)	p-cymene (10.75%)	Limonene (16.28%)	α-phellandrene (32.09%)	*E. cinerea*	Sefidkoh Lorestan	[18]
	p-cymene (2.72%-12.05%)	β-phellandrene (10.29%–11.08%)	α-pinene (12.28%–25.54%)	α-phellandrene (42.40%–54.87%)	*E. cinerea*	Chaharmahal va Bakhtiari	[24]
	α-pinene (5.18%)	p-cymene (12.84%)	Z-β-ocimene (17.28%)	α-phellandrene (40.64%)	*E. cinerea*	Khorram Abad	[67]
Carvacrol (3.15%)	α-pinene (3.31%)	Terpinolene (3.41%)	α-phellandrene (21.88%)	p-cymene (34.43%)	*E. cinerea*	Khorram Abad	[67]
Limonene (5.40%)	p-cymene (7.50%)	β-phellandrene (9.80%)	α-pinene (16.50%)	α-phellandrene (40.60%)	*E. cinerea*	Kohgiluyeh Boirahmad	[68]
β-phellandrene (6.66%)	α-pinene (8.30%)	Carvacrol (19.12%)	p-cymene (16.32%)	α-phellandrene (24.08%)	*E. cinerea*	Khorram Abad	[5]
Limonene (3.40%)	p-cymene (6.10%)	α-Pinene (9.60%)	β-phellandrene (10.70%)	α-phellandrene (61.40%)	*E. cinerea*	Fars Abadeh	[69]
β-phellandrene (3.70%)	p-cymene (8.30%)	δ-3-carene (17.40%)	α-phellandrene (16.30%)	Methyl eugenol (50.40%)	*E. sibthorpiana*	Taleghan Tehran	[70]
	β-Phellandrene (5.30%)	Methyl eugenol (16.90%)	α-phellandrene (31.0%)	Δ-3-carene (31.90%)	*E. sibthorpiana*	Velenjak Tehran	[71]
α-humulene (3.30%)	Germacrene D (3.70%)	Bicyclogermacrene (4.50%)	Carotol (9.50%)	Spathulenol (10.50%)	*E. orientalis* (seed)	Islami Island	[27]
	α-Pinene (7.70%)	1,7-octadiene, 3,6-dimethylene (10.0%)	p-cymene (11.50%)	Myrcene (20.90%)	*E. orientalis* (shoot)	Islami Island	[27]
	Myrcene (3.0%)	Falcarinol (4.80%)	Terpinolene (24.40%)	Myristcin (52.90%)	*E. orientalis* (root)	Islami Island	[27]
	α-Phellandrene (8.22%)	p-cymene (14.34%)	α-Pinene (16.70%)	β-myrcene (32.10%)	*E. orientalis*	Eastern Azerbaijan	[72]
Cis-3-hexylbenzoate (4.60%)	Spathunenol (4.60%)	Limonene (6.60%)	Δ-3-carene (16.20%)	Z-β-ocimene (26.70%)	*E. platyloba*	Shalamzar	[28]
Geraniol (3.0%)	E-sesqui-lavandulol (5.59%)	Carvacrol (7.22%)	Trans-ocimene (20.89%)	Thymol (27.19%)	*E. platyloba*	Chaharmahal va Bakhtiari	[31]
Nerolidol (5.66%)	γ-dodecalactone (5.84%)	α-pinene (7.69%)	2,3-dimethyl-cyclohexa-1,3-diene (9.87%)	Ocimene (26.51%)	*E. platyloba*	Maragheh	[35]
Dimethyl styrene isomer (5.28%)	Dimethyl styrene (6.55%)	Eugenol (6.74%)	Anethole (7.39%)	Asarone (10.15%)	*E. platyloba*	Torbat-Heydariye	[37]
Nerolidol (5.66%)	α-pinene (7.69%)	γ-dodecalactone (9.12%)	2,3-dimethyl-1,3-cyclohexadiene (9.87%)	Ocimene (26.51%)	*E. platyloba*	Maragheh	[50]
Myristicin (5.21%)	Limonene (5.77%)	Spathunenol (5.89%)	p-cymene (10.98%)	Z-β-ocimene (33.06%)	*E. platyloba*	Chaharmahal va Bakhtiari	[65]
Spathunenol (4.57%)	Cis-3-hexylbenzoate (4.57%)	Limonene (6.59%)	Δ-3-carene (16.16%)	Z-β-ocimene (26.71%)	*E. platyloba*	Shalamzar	[73]
Myrcene (4.40%)	Linalool (5.60%)	α-pinen (6.0%)	γ-decalactone (8.49%)	E-β-ocimene (49.9%)	*E. platyloba*	Damavand Tehran	[74]
Cis-β-ocimene (2.30%)	Linalool (3.10%)	Myrcene (6.0%)	2-furanone (6.20%)	trans-β-ocimene (67.90%)	*E. platyloba*	Alvand Mountain	[75]
α-pinene (3.40%)	β-Phellandrene (6.30%)	p-cymene (7.40%)	α-phellandrene (24.50%)	Z-β-ocimene (38.90%)	*E. platyloba*	Maragheh	[76]
Caryophyllene oxide (2.86%)	Methyl eugenol (3.01%)	Z-β-ocimene (4.23%)	E-β-ocimene (21.56%)	γ-decalactone (43.96)	*E. platyloba*	Binaloud Mountain Nishapor	[77]

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Table 1: Contd...

Major essential oil constituents					Species of *Echinophora L.*	Plants collect regional	References
p-cymene (4.20%)	α-phellandrene (6.80%)	Myrcene (12.50%)	Sabinene (15.20%)	Z-β-ocimene (18.40%)	*E. platyloba* (rosette)	Kherameh	[78]
Δ-3-carene (5.10%)	p-cymene (7.10%)	α-phellandrene (13.0%)	Sabinene (16.40%)	E-β-ocimene (16.80%)	*E. platyloba* (floral budding)	Kherameh	[78]
α-phellandrene (8.10%)	β-phellandrene (9.20%)	E-β-ocimene (10.0%)	Myrcene (10.50%)	Sabinene (16.0%)	*E. platyloba* (full flowering)	Kherameh	[78]
p-cymene (3.18%)	n-heptanol (7.09%)	α-pinene (7.29%)	R-D-decalactone (14.98%)	E-β-ocimene (42.19%)	*E. platyloba*	Taghboostan Kermanshah	[79]
β-phellandrene (2.70%)	n-heptanol (6.27%)	α-pinene (6.43%)	R-D-decalactone (12.75%)	E-β-ocimene (53.81%)	*E. platyloba*	Taghboostan Kermanshah	[79]

E. cinerea: *Echinophora cinerea*; *E. sibthorpiana*: *Echinophora sibthorpiana*; *E. orientalis*: *Echinophora orientalis*; *E. platyloba*: *Echinophora platyloba*

shows that in most of the studies reported of *E. cinerea*, any combination of the alpha-phellandrene compound has been identified as the highest among species diversity, but there are major differences in the other species. Differences in chemical composition of essential oils through the results and published reports can be caused by differences in the harvest season, weather conditions, geographic region of growing, parts of plants, extraction methods, and time.

Extract

The secondary metabolites have been reported from the extracts of this genus containing saponins, alkaloids, and flavonoids.[29,30] Flavonoids are one of the most important phenolics that are found in the nature freely and in glycosides form. Flavonoids and their close compounds are often yellowish. In Latin, *flavus* means yellow. Flavonoids are also used as a valuable indicator of chemotaxonomy in plant.[80,81] Hadjmohammadi *et al*. reported quercetin in *E. platyloba* by HPLC method in the range of 94%–99%.[82] Shokohiniya and Rashidi identified quercetin and kaempferol (flavonoid)[83] and three polyacetylenes, one monoterpenoid glycoside, and prenylated coumarin[84] in *E. cinerea* species. Valizadeh *et al*. isolated stigmasterol, sitosterol, stigmasterol-β-D-glycoside, and saccharose from *E. platyloba*[85] [Figure 2].

CHEMICAL RELATIONS OF COMPOUNDS AND BIOLOGICAL EFFECT

According to the results of the other studies, *Echinophora* genus is the source of phenolic compounds and flavonoids that they have strong antioxidant activity.[28-30] Phenolic compounds are the known representative of giving hydrogen to free radicals and thus break the chain reactions of oxidation of lipids in the first step. This high potential of phenolic compounds is to inhibit free radicals related to the phenolic hydroxyl group.[28] Thus, antioxidant properties of phenolic compounds depend on their ability to give electrons to trap and remove free radicals by the formation of stable phenoxyl compounds.[86] Antibacterial effects of essential oil of this plant can be associated with materials such as carvacrol, linalool, p-cymene, α-pinene, and terpinene.[23] In another study, the antibacterial activity

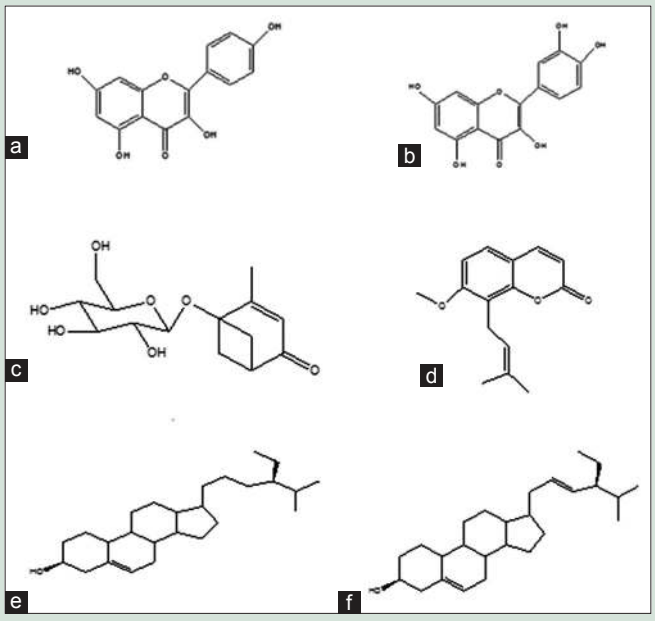

Figure 2: Molecular structure of some isolated metabolites: (a) kaempferol, (b) quercetin, (c) prenylate coumarind, (d) stigmasterol, (e) stiosterol, (f) stigmasterol-beta-D-glycoside

of the essential oil was associated to ocimene, α-pinene, myrcene, and α-phellandrene.[35] Other research has shown that this plant has saponins, alkaloids, and flavonoids compounds, so it has the antibacterial and antifungal effect of *Echinophora* methanol extract.[33] In other studies, the main components of essential oil in other reviews such as trans-β-ocimene, 2-furanone, myrcene, linalool, cis-β-ocimene,[75] asarone, anethole, eugenol, dimethyl styrene, dimethyl styrene isomer, nuciferol, cedran, and isosafrole have antibacterial effects.[37] Various chemical substances use multiple different mechanisms to destroy microorganisms. Among them, the most important feature of this group is its being hydrophobic so that by entry to the membrane of the bacteria cell and mitochondria, the performance of the cells disrupts and the permeability increases, and thus, ions and other cell compounds exit, which lead to the death of microorganisms.[5,23] The anticancer and cytotoxic activity of *E. platyloba* has been reported because this plant is the rich source of monoterpenes, sesquiterpenes, and phytochemical compounds such as betulinic acid and ursolic acid, which lead to induce apoptosis or cell death.[53] Studies have shown that plant compounds such as flavonoids directly affect the pituitary gland, especially the part that secretes the hormone LH, and lead to increased levels of progesterone. This can result in somehow moderate disorders and consequently loss of hormones in the menstrual, such as premenstrual syndrome and dysmenorrhea.[47,54,87] Since the muscles in the human uterus are smooth muscles, the extract of this plant can probably apply its antispasmodic effect on it, resulting in the pain reduction during menstruation.[57] Compounds such as saponins, alkaloids, flavonoids, and terpenes in this plant can reduce body weight and blood fat and protect liver and kidney. Moreover, the extract of this plant has antioxidant compounds such as coumarin, polyacetylenes, flavonoids, sesquiterpenes, and phthalides which can reduce malondialdehyde and inhibits lipid peroxidation. On the other hand, lactase enzyme increases and enzymes in the liver decrease. Polyphenolic compounds and flavonoids can also revive the cells against glutathione depletion and protect them by increasing the capacity of anti-oxidant enzymes (glutathione, glutathione reductase, glutathione peroxidase, and catalase). Thus, it may strengthen the antioxidant properties to deal with oxidative stress may boost and may have protective effects on the liver and kidneys functioning. Some plant compounds through energy consumption and some compounds such as quercetin and linoleic acid inhibit adipogenesis and induce apoptosis in cells as lipid-lowering blood fat goes away. Moreover, the extract components (phytochemicals) may reduce fat absorption from food, proliferation, and differentiation of precursor fat cells to reduce energy consumption and increase the breakdown of fat accumulated in the body.[60] It seems that the analgesic effect of the extract is due to opioid receptors. Flavonoids by inhibiting the activity of N-methyl D-aspartate receptor activity reduce intracellular calcium followed by a decline in nitric oxide synthase enzyme activity and calcium-dependent phospholipase A_2 to secular. As a result, by the reduction of nitric oxide and prostaglandins, especially prostaglandin E_2 and $F_2\alpha$, they show analgesic effect. Moreover, analgesic effects of saponins inhibit the enzyme synthesis inducing analgesic effects of nitric oxide (iNOS) and cyclooxygenase synthesis (COX-2). Hence, the extract of *E. platyloba* with both environmentally and centrally moderates pain leads to increased resistance to pain and decreased responsiveness to acute and chronic pains.[65] Flavonoids and phenolic compounds in the extracts of *Echinophora* with their antioxidant effects increase the speed of healing of open ulcer of skin. Therefore, the topical use of an ointment containing *E. platyloba* leaf extract boosts the main restoration phase cells (macrophages) and a significant increase in vascular regeneration in the first phase of wound healing. It can also reduce inflammation due to the antibacterial properties. In the second phase of wound healing process by cell proliferation due to increase in migration of fibroblasts and the beginning of regeneration of cover tissue and finally stage of wound healing, epithelial tissue significantly increases secretion of collagen at the wound site and the thickness of the coating and consequently increases the speed of recovery in the final process of wound healing.[64]

PHARMACEUTICAL TRADE PRODUCTS

So far, herbal medicine has not been produced commercially from any of the species *Echinophora*. However, due to the multiple medicinal properties of this plant, more attention of the researchers and pharmacists is required in the production, processing, and appropriate use of this plant.

INTERFERENCE OF THE PLANT WITH MEDICINE

According to the survey conducted in monographs WHO, the German Commission E, PDR Herbal medicine book, and search engines Scopus, Google Scholar, and PubMed, so far, no interference of this plant has been reported.

CONCLUSION

Echinophora is a medicinal and aromatic plant that mainly has domestic consumption and used dry powder with yogurt and buttermilk as deodorant and due to antifungal properties that can be caused by homemade food such as pickles, sauce, and cheese. *Echinophora* has considerable antibacterial and antioxidant properties. Essential oils and extracts of this plant are effective against human pathogens bacteria that are an important cause of nosocomial infections and can be used in the future microbicides plants. It can also be hoped that due to its medicinal properties and ingredients, it also can be used in the pharmaceutical, food, and cosmetics industries.

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Conflicts of interest

There are no conflicts of interest.

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