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Miracle plant Eryngium foetidum Linn- A review on Ethnobotanical, Phytochemical composition and Pharmacology

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Abstract

*Medicinal and edible plants play a crucial role in the prevention and mitigation of different human diseases and disorders from ancient times till today. Eryngium foetidum Linn (family Apiaceae) commonly known as "Wild coriander" or "spiny coriander" is one such herb native found in Mexican country. However, today this herb is also found growing in all parts of the tropical and subtropical regions of the world including India. In India it is used as an ethnomedicinal plant used for the treatment of number of ailments such as fevers, cold, cough, vomiting, burns, fevers, hypertension, headache, earache, stomachache, asthma, arthritis, snake bites, scorpion stings, diarrhea, malaria and many other diseases. Studies suggest that leaves contain medicinally important compounds, particularly rich in triterpenes and saponins. Particularly in leaves indicate the presence of flavonoids, tannins, a saponin and several triterpenoids, but no alkaloids were reported. A significant constituent of the essential oil of the plant is E-2-dodecenal ("eryngial"), with isomers of trimethyl benzaldehyde. Preclinical studies from the past several years have shown that the extracts prepared from E. foetidum possess antibacterial, antifungal, anti-carcinogenic, free radical scavenging, anti-hyperglycemic, anti-neoplastic, gastroprotective, and diuretic effects. In this review attempt made to address the chemical constituents, medicinal uses and validated pharmacological observations of E. foetidum.***

Keywords: *E. foetidum*, phytochemical constituents, ethnomedicinal uses, pharmacological studies

Introduction

Medicinal plants have been used as traditional medicine and as ethnomedicine all over the world. Medicinal plants and have been the basis of treatment of various diseases. 80% of the world population still depends on herbal medicine. Secondary metabolites produced by medicinal plants plays an important role in plant physiology mainly acts as antioxidant, antiallergic, anti-inflammatory, anticancer, antihypertensive and antimicrobial activities [1].

Some medicinal plants are known for its effective drugs for human disease treatments [2, 3]. In addition to their efficacy, most of the medicinal plants are non toxic and therefore, they can be used as safe therapeutic strategies [4]. A plethora of scientific evidence reported that edible and medicinal plants have significant potential to synthesize antimicrobial agents as their defense mechanisms against biotic stresses, such as microorganisms [5]. It has been reported that plant derived antimicrobial phytochemical compounds such as phenols, flavonoids, terpenoids, lectins, polypeptides as well as polyacetylenes [6]. Additionally, in traditional medicine many edible and medicinal plants have been widely used for the treatment of either infectious or chronic diseases. The use of medicinal plants increases due to its easy availability, affordability and accessibility and to the often high cost and adverse effects of standard synthetic drug agents [7].

Eryngium foetidum Linn. commonly known as 'Wild coriander' or "spiny coriander" are widely used in different parts of the world as flavouring agents. Plant morphology and appearance of *E. foetidum* and coriander is quite different, but the leafy aromas almost similar with each other. The leaves of these plants are used in traditional Indian cuisine to improve the smell and taste of the food. However, the aroma of spiny coriander is deeper and stronger than the coriander. It is used as an ethno-medicinal plant for the treatment of a number of ailments such as fevers, chills, vomiting, burns, fevers, hypertension, headache, earache, stomachache, asthma, arthritis, snake bites, scorpion stings, diarrhea, malaria and epilepsy [8]. The main constituent of essential oil of the plant is eryngial (E-2-dodecenal).

A pharmacological investigation claims to have demonstrated anthelmintic, anti-inflammatory, analgesic, anticonvulsant, anticlastogenic, anticarcinogenic, antidiabetic, and antibacterial activity [9].

The genus *Eryngium* contains more than 250 flowering species world wide [10]. Among them *E. foetidum* is domesticated, cultivated and most complex genus in *Eryngium* family. According to latin 'foeti' means "foul smell" so it is called '*foetidum*'[11].
According to morphological studies the genus *Eryngium* has been classified into

Kingdom: Plantae,
Order: Apiales,
Family: Apiaceae,
Genus: *Eryngium,*
Species: *E. foetidum*

Botanical description

Leaves: Leaves are aromatic which smells as coriander, glabrous, erect, perennial herb, spinous, toothed, leaves are longer in lower end and smaller near flowering branches, green, glabrous and oblanceolate (13-30 cm) long, 3-4 cm wide. Leaves are in margin serrulate, fleshy and waxy oblanceote which were arranged spirally around the short-thick stem which forms rosette. The leaf margin is serrate and each tooth to the margin contains a small yellow spine. The lower leaves have short petiole, but upper leaves are sessile [12].

Flowers: usually flowering will take place once in two months. Cluster of flower heads in spikes forming the characteristic whitish umbel inflorescence on a long stalk (25-50 cm) arising from the center of the leaf rosette. Flowers are sessile, actinomorphic, bisexual and pentamerous [12]. Sepals are given, tubular, acute and persistant which is longer than petals, white petals are white, narrow, oblonged and notched. Stamens are free and alternate with petals the filaments are white and longer than the petals along with pale yellow dithecous anthers as shown in fig. 1.

Gynoecium: It consists of a compound pistil with 2 carpels and styles and the inferior ovary with 2 locules.

Fruit: It is globose ovoid in shape and covered with rounded protrusions of 1-2 mm long, Fruits are ellipsoid, egg shaped schizocarps (1.5 mm long) covered by round bumps.

Fig.1. Leaves and inflorescence of *E. foetidum*

Distribution: ***E foetidum*** is a native of Southern Mexico and tropical America and later identified in Panama and Caribbean islands [13]. It is also grown in tropical Africa, South Asia, Southern parts of Europe and Pacific islands [14]. Spiny coriander has been introduced to Northern America. In 1900s, *E. foetida* was introduced by Chineese into South-East Asia (India, Thailand, Vietnam, Singapore, Malaysia, Indonesia, Bangladesh, Sri-lanka and Myanmar) as a substitute of the *Coriandum sativum* L. [15, 16]. It is one of the most common weed in Northern part of Iran and Nigeria and widely used in salads and common edible food components [17].

Cultivation: Shaded areas produce plants with greener leaves and are more marketable because of their better appearance and higher pungent aroma [18]. Cultivating the *E. foetidum* under 50-75% artificial shade conditions using shade-net would be the best strategies for increasing yield. *E. foetidum* has been termed as different names in different languages in the world and in India as shown in table 1 and 2.

Table 1. Names of *E. foetidum* Linn in various languages [12]

Language	**Names**
Hindi	Bhandhania
English	Black benny, saw leaf herb, Mexicon coriander, saw tooth coriander, spiny coriander
Bangladesh	Bilatidhonia
Sri lanka	Andu kola
Chinese	Ci yuan sui
Nepali	Dhaniya vermeil
French	Chardon
Caribean countries	Culantro
Trinidad	Shadobeni
Dominica	Chardron benee
Guyana	Fitweed
Haiti	Coulante
Puerto Rico	Recao
German	Langer coriander
Indonesia	Walangan
Malaysia	Ketumbar
Thailand	Pak chi farang
Japanese	Nokogiri korianda
Vietnamese	Ngo gai
Spanish	Racao recao
Panama	Culantro
French	Chardon
Urdu	Fragistan

Table 2. Names of *E. foetidum* Linn in Indian languages [12]

Language	**Names**
Hindi	Bhandhani
Mizoram	Bahkhawr
Manipuri	Awa phadigom
Nagaland	Dunia
Sanskrit	Phiranga
Tamil	Piranga
Malayalam	African malli
Kannada	Kaadu kottambari

Market potential: Spiny coriander has huge market potential for cosmetic and perfumery industries pharmaceutical companies for formulation of various types of products and drugs. Extract rich in eryngial has been patented for the treatment of parasites in humans and other mammals [19, 20]. Moreover, skin whitening agent produced from the leaves of *E. foetidum* was patented by Japaneese [21].

Traditional Uses of *E. foetidum*

It is an important spice-cum-culinary herb used for garnishing, marinating, flavouring and seasoning in soups, curries, chutneys, snacks and meat dishes in Asian countries including India. The leaves are mixed in smaller quantities, its pungent unique aroma gives the characteristic flavour to the dishes [12]. In china it is widely used for the treatment of inflammation and several diseases as traditional medicine [9]. In Thailand people used to treat toothache and digestive problems [22]. In Caribbean countries it has been traditionally used for veneral and gastrointestinal problems [23]. In northern part of Iran leaves were used for its multiple beneficial effects on human health [24]. Peoples used to cure diahorrea and headache in Turkey. So most of the people's from all over the world use the leaves for the treatment of kidney and bladder dysfunctions and also used as an ethnomedicinal plant for the treatment of a number of ailments such as fevers, chills, vomiting, burns, fevers, hypertension, headache, earache, stomachache, asthma, arthritis, scorpion stings, malaria and diahorrea [25]. From the leaves decoction and infusion were prepared to cure fever, flu, diabetes, hypertension, constipation diuretic, anti-convulsant, cold, muscular pain in South East Asia [26, 27]. In Carrabian island dry leaves were used to cure diarrhea, stomach ache, cold, fever nausea, malaria [28]. In Malaysia decoction were prepared from the leaves of *E. foetidum* to cure abdominal pain, digestive ailments, and vaginal infections. Leaves, roots and fruits are crushed and taken even for snake bite [29, 30]. It is also mixed with milk and taken as a juice for the treatment of asthma and cold [31]. In Guyana and Dominica whole plant were crushed and used to cure Abscess, boils, child birth complications, infertility, menstrual pain and female complications [32, 33]. Trinidad people's were reported to use leaves decoction for abortion induction and sexual dysfunction and roots infusion were used to control worm infections in stomach [27]. A plethora of evidence has pointed out to multiple pharmacological effects on anthelmintic, anti-inflammatory, analgesic, anticonvulsant, anticlastogenic, antihemolytic, anticarcinogenic, antidiabetic, and antibacterial activity because of the presence of phytochemicals [34, 35, 36].

Chemical constituents of leaves: Fresh leaves contains 87% moisture, 6.5% carbohydrate, 3.3% protein, 0.6% fat, 1.7% ash, 0.06% Phosphorous, 0.02% iron, Vitamin A (10 IU/100g), vitamin B_2 (60 mg/100 g), vitamin C (150-200 mg/100g). On a dry weight basis leaves consist of 0.1–0.95% volatile oil, 27.7% crude fiber, 1.23% calcium, and 25 ppm boron [37]. It also contains saponins, flavonoids and essential oil, while the root contains triterpene saponins, monoterpene glycosides, phenolic compounds such as phenolic acids, coumarin derivatives, terpene aldehyde esters, acetylenes, essential oils and oligosaccharides [38].

Phytochemistry:

Saponins and flavonoids are the rich source in *E. foetidum* which includes triterpenoids. The presence of triterpenoids were α- cholesterol, Campesterol, Stigmasterol, δ5-24 stigmasta dienol, β-sitosterol, Brassicasterol, Clerosterol, δ-5- Avenasterol, and δ-7- avenasterol isolated from leaf part [37]. Eleven steroids have been identified from *E. foetidum* which includes δ-sitosterol [40], stigmasterol [41], campesterol [42], brassicasterol [43], 3α- cholesterol [44], (E)-clerosterol [45], α 5 – avenosterol [46], E-7 –avenasterol, and β-5,24-stigmastadienol from the leaves [47]. Leaves are reported to be rich in alphacholesterol, brassicasterol, campesterol, stigmasterol as the main component (95% clerosterol, beta-sitosterol, delta 5-avenasterol, delta-5-24-stigmastadienol and delta 7avenasterol). Presences of carbonyls were more in leaf and aerial part of the plants. 2,4,5-Trimethylbenzaldehyde, 2,3,6-Trimethylbenzaldehyde, (E)-2- Dodecenal, E-2- Tetradecenal, 2,4,5-Trimethylbenzaldehyde, 3-dodecenal, E-2- Tetradecenal were present [47]. Aldehydes and acids like carotol, Hexadecanoic acid, (E)- dodecenoic acid, dodecanoic acid, capric acid were identified in the

leaf part of the *E. foetidum* whereas root and seeds contains a lesser amount of carbonyl, alcohol and terpenes as shown in table 3.

Table 3. Compounds present in *E. foetidum*

Sl. No	Parts of the plant	compounds	Compound name	References
1	Leaves	Triterpenoids	α- cholesterol	[41]
2			Campesterol	
3			Stigmasterol	
4			δ-5-24 stigmasta dienol	
5			β- sitosterol	
6			Brassicasterol	
7			Clerosterol	
8			δ-5- Avenasterol	
9			δ-7- Avenasterol	
11	Leaves	Carbonyls	2,4,5- Trimethylbenzaldehyde	[48, 49]
12			2,3,4- Trimethyl benzaldehyde	[50]
13			(E)-2- Dodecenal	[51, 14]
14			Z-2- Dodenal	[52, 53]
15			3- Dodecenal	[49, 50]
16			(E)-2- Decenal	[54]
17			(E)-4- Decenal	[49]
18			(E)-2- undecenal	[54]
19			Dodecenal	[54]
20			7- Octadecenal	[55]
21			E-2- Tetradecenal	[55]
22			E-2- Tridecenal	[55]
23			H-Hydroxy-3, 5- dimethyl acetophenone	[56]
24			Duraldehyde	[55]
25			5- undecanone	[56]
26	Leaves	Alcohols	Carotol	[55, 49]
27	Leaves	Acids	Hexadecanoic acid	[49]
28			(E)- Dodecenoic acid	[51, 55]
29			Dodecanoic acid	[51, 55]
30			Capric acid	[16]
31		Terpenes	α- pinene	[55]
32			ϒ- Terpinene	[55]
33			Limonene	[16]
34			Caryophyllene oxide	[55]
35	Aerial parts	Saponins	0-3-{β-D- glucopyranosyl-(1→ 2 rham)- a- L-rhamnopyranosyl-(1→ 4 glu)- β- D-glucopyranosyl}- olean -12-en23, 28- diol	[17]
36		Carbonyls	2,3,6-Trimethylbenzaldehyde	[56]
37			(E)-2- Dodecenal	[56]
38			E-2- Tetradecenal	[56]

39			2,4,5-Trimethylbenzaldehyde	[55]
40			3-dodecenal	[48]
41			Lauraldehyde	[48]
42	Roots	alcohol	2- formyl-1, 1,5-trimethyl cyclohexa-2,4-dien-6-ol	[14]
43			Falcarinol	[48]
44		Carbonyl	2,3,6- Trimethylbenzaldehyde	[14]
45	Seeds	Alcohol	carotol	[49]
46		Terpenes	(E)- β- Farnesene	[49]
47			(E)- Anethole	[49]
48			α- pinene	[49]

Essential oil composition from *E. foetidum* were reported from many researchers as illustrated as shown in the table. Most common compound present in essential oils is (E)-2dodecenal, decanal and dodecanal (Martin, 2005). Essential oil isolation and extraction was reported by the method, hydro distillation followed by The GC and GC/MS analysis [10, 57].

The highest per centage of compound E-2- dodecenal was recorded is (59.72%).
carboxylic acids were found to be 12- 30%, respectively [58]. [16] Chowdhury *et al*, 2007 isolate the essential oil from leaves of *E. foetidum* by hydro-distillation method and sixty compounds have been identified with 2- dodecenal (E) (37.4 %), dodecanoic acid (10.7 %), trans-2-dodecanoic acid (9.7 %), 2-tridecenal(E) (6.7 %), duraldehyde (5.1 %) and tetradecanal (4.4 %) as the major constituents. Other major constituents were 2-undecenal (1.7 %), 7-octadecenal (3.7 %), capric acid (1.9 %), caryophyllene oxide (1.2 %), capraldehyde (1.2 %), durylic acid (2.3 %), α-durenol (2 %) and limonene (2 %). Many reports were also confirmed the higher percentage of (E)-2-dodecenal as major constituent extracted from leaves [27, 57. 60] Banout *et al*, 2007, reported that (E)-2- dodecenal being the main constituent from the *E. foetidum* leaves with a higher range of 61.8–62.2%, followed by n-dodecanal (10.9–15.5%), (E)-2- tetradecenal (7- 7.6%) and 1-tetradecene (3.6–5.7%). Aldehydes such as decanal and dodecanal are very significant constituents of the essential oil of *E. foetidum*, because of its presence it has a huge demand in flavor and fragrance industry [61]. Essential oil obtained from the root is dominated mainly by unsaturated alicyclic or aromatic aldehydes (2,3,6-trimethylbenzaldehyd 40%, 2-formyl-1,1,5-trimethyl cyclohexa2,4-dien-6-ol (20%,) [27]. From the seeds, it is dominated with sesquiterpenoids (carotol 20%, ß-farnesene 10%), phenylpropanoids (anethole) and monoterpenes (a-pinene) but no aldehydes were reported from seeds [62]. Compounds present in the leaves, roots and seeds from the extracted oil are as shown in table 4.
Table 4 Compounds present in the leaves, roots and seeds from the extracted oil

Sl. No.	**Part**	**Name of the compound**	**Reference**
1		Nonane	[14]
2	Leaves	Undecane	[14, 55]
3		Tridecane	[14, 55]
4		1-hexanol	[14]
5		1-Dodecanol	[56, 14]
6		(E)- 2-Dodecen-1-ol	[14]
7		(E)-2-Tetradecen-1-ol	[14]
8		Z-3-Hexen- 1-ol	[14]
9		1-Octen-3-ol	[14]
10		Nonanal	[14]

11		Decanal	[14]
12		Undecanal	[14, 55]
13		Dodecanal	[14, 55]
14		Tetradecanal	[14, 63, 55]
15		E-2-Decenal	[14, 63, 55]
16		E-2-Undecenal	[14, 63, 55]
17		E-2-Dodecenal	[27, 61, 12, 9]
18		E-2-Tridecenal	[27, 61, 12, 9]

19	Aerial part	E-2Tetradecenal	[12, 9]
20		E-2Hexadecenal	[9]
21		2.09Z-2-Dodecenal	[12, 9]
22		Z-2Tetradecenal	[12, 9]
23		Z-4Tetradecenal	[55]
24		Benzaldehyde, 2,4,6- trimethyl	[55]
25		Benzaldehyde, 2,4,5- trimethy	[27, 63, 61, 12, 9]
26		E,E-2,4-Dodecadienal	[9]
27		14 a-Pinene	[34, 61, 12, 9]
28		Sabinene	[34, 9]
29		β –Pinene	[12, 9]
30	Leaves	β –Myrcene	[12, 9]
31		Benzene, 1,2,3- trimethyl-p-Cymene	[34]
32		Hexadecanoic acid	[22, 55]
33		(E)-2-Dodecenoic acid	[12, 9]
34		Eucalyptol	[12, 9]
35		γ-Terpinene	[27]
36		E-linlool oxide	[14]
37		1-Undecene	[14]
38		Z-Linalooloxide (furanoid)	[14]
39		Linalool	[14]
40		α-Pinene oxide	[14, 55]
41		Camphenone,6	[14]
42		Limonene oxide	[14, 55]
43		2-Undecanone	[14]
44		α –Copaene	[14]
45		α -E-Bergamotene	[14]
46		β-Ionone	[14]
47		Germacrene A	[14]
48		E-Nerolido	[14]
49		β -Caryophyllene oxide	[14]
50		α-Copaene	[34]
51		1- Tetradecena	[34]
52		Thujopsene	[34]
53		β- Chamigrene	[34]

54		A- Muurolene	[34]
55		δ- Cadinene	[34]
56		(E.E)-2.4-dodecadienal	[34]
57		4-Hydroxy-3,5 dimethylacetophenone	[34]
58		Apofarnesol	[34]
59	Roots	Hexadecane	[34]
60		(E)-4-Decenal	[14]
61		7-Octadecanal	[49]
62		2,3,4-Trimethylbenzaldehyde	[51]
63		α-Copaene	[49]
64		5-Undecanone	[14]
65		Carotol	[51, 64, 14]
66	Seeds	Limonene	[22, 55]
67		2,3,4-Trimethylbenzaldehyde	[49]
68		α-pinene	[51, 64, 14]

Biological & Pharmacological activities of *E. foetidum*

E. foetidum contains variety of active phytoconstituents and thus possess various kinds of biological and pharmacological activities. It possess activities like antibacterial, antiinflammatory, analgesic, anti-cancer, anti-oxidant, antihyperglycemic, anticlastogenic, antihemolytic, anti-diabetic and cytotoxic affects ([33, 35]).

Antimicrobial effects of *E. foetidum*

Plants are known to produce antimicrobial substances [5], which act as plant defence mechanisms and protect them against abiotic and biotic stress. These antimicrobial compounds present in the medicinal plants have adverse effects and wide spectrum activities against the pathogens. This is because of the secondary metabolites present in the plants such as alkaloids, phenolics, polyphenolics, terpenoids, lectins, polypeptides and polyacetylenes [6]. *E. foetidum* exhibit considerable antimicrobial activity against gram positive and gram negative bacteria, and also some species of fungi. [42] Ndip *et al*., (2007), reported the methanolic extract of leaves showed moderate anti-bacterial activity against 6 strains of *Helicobacter pylori* isolated from gastric biopsy samples. [57] Martin *et al*., 2003, reported anti-bacterial activity from methanol extraction of aerial part of the plants exhibited against *Salmonella* species and *Erwinia* sps. Essential oil rich in eryngial is subjected to US patent application against parasitic trypanosomes, nematodes, fungi and bacteria [55]. [65] Alzoreky and Nakahara (2006) reported that the acetone and buffered methanol extracts did not showed any antibacterial activity against *Escherichia coli*, *Salmonella infantis*, *Listeria tottori*, *Staphylococcus aureus* and *Bacillus cereus*. In another study [66] Guevara *et al*., 2000, evaluated the *in vitro* bactericidal effects against plant pathogenic bacteria *Erwinia* genus of Enterobacteriaceae which causes diseases on mango (*Mangifera indica*), sun flower (*Helianthus annuus*,), papaya (*Carica papaya*) and banana (*Musa* sp.), the greatest effects were found with leaf extracts of *E. foetidum* thereby revealing a possible role as a pest control agent in the agriculture industry. In yet another study by [67] Kubo *et al*. 2004, isolated pure E -2- dodecenal ("eryngial") from leaf showed potent activity against *Salmonella choleraesuis* at 6.25 μg/mL [68]. [60] Banout *et al*., (2015) reported *E. foetidum* of methanol leaf extracts showed potential effective against *Staphylococcus aureus* among the tested organisms *Pseudomonas aeruginosa* and *Staphylococcus aureus* at concentrations 75 and 100 micrograms per mille litre respectively.

Anti-plasmodial and anti-anthelmintic activity

E. foetidum was tested for its anti-plasmodial activity, using chloroquine as positive control to evaluate the sensitivity of susceptible *Plasmodium falciparum* strains at IC_{50} 25μ g/mL. The result suggests the potential of the plant has anti-malarial drug for malaria disease [43]. [69] Mariath, *et al*., 2009 reported by screening with the aqueous extract of the entire plant against *Plasmodium gallinaceum* which infects erythrocytes which adhere to microvessels in the chickens, thereby suggesting *E. foetidum* can be used in veterinary treatment. *In vitro* anthelmintic activity of *E. foetidum* showed potential activity against trematode parasite, *Paramphistomum* sp. When the parasites were exposed to different concentrations of leaf extracts (20 and 50 mg/mL PBS), a dose-dependent anthelmintic activity was observed at 50 mg/mL showed that plant also has an anthelmintic effects [70].

Anti-leishmanicidal activity: Leishmaniasis is one of the most widespread protozoan infections in humans after malaria [71]. This disease is caused by protozoan of the genus Leishmania and transmitted by sand flies (Lutzomyia and Phlebotomus genera) which results in significant disability and morbidity among affected people [72]. Leishmanicidal treatments have may cause some toxic side effects, and till now there is no vaccine available [73]. [74] Rojas-Silva *et al*., 2014 reported leishmanicidal activity through fractionation procedure using a leishmanicidal assay. As a result, two compounds Lasidiol p-methoxybenzoate, a daucane sesquiterpene and 4-hydroxy-1,1, 5-trimethyl-2-formyl-cyclohexadien-(2,5)- [αacetoxymethyl-cis crotonate] and terepene aldehyde ester derivative isolated from aerial part of *Eryngium foetidum*.

Anti-convulsant activity

A pharmacological evaluation using 3 mL of an aqueous extract prepared at a concentration of 110 g/250 mL demonstrated anti-convulsant activity in rats with picrotoxininduced (4.5 mg/kg i.p.) convulsions [43]. Aqueous extracts of leaves and stems, when administered intraperitoneally to rats, showed effective in treating epilepsy as the phenobarbitone control [43, 75].

Antioxidant activities

There is currently an upsurge of interest in phytochemicals as new sources of natural antioxidants. In several *in vitro* antioxidant activity screening of *E. foetidum* on different parts have been demonstrated to have the antioxidant activity in tested models. The roots of *E. foetidum* were shown to have high antioxidant activity toward DPPH (2,2-diphenyl-1picrylhydrazyl) radical in a TLC autographic assay. [57] Martin *et al*., 2005 reported the antioxidant activity by screening the whole plant of *E. foetidum* showed the anti-oxidant compounds present will increase the scavenging activity due to the presence of phenols, vitamin and flavonoids present possessed the strong effects on reducing DPPH radical scavenging with highest 78% comparing with standard ascorbic acid. There is currently an upsurge of interest in phytochemicals as new sources of natural antioxidants. [76] Chanwitheesuk *et al*., 2005 from Thailand reported IC_{50} of 32.7 mg/mL from leaves and 17.5 mg/mL from inflorescence, respectively. [77] Khaled *et al*., 2007 from Jordanian origin reported IC_{50} for DPPH radical-scavenging activity was 38.0 from leaves and 14.3 mg/mL from inflorescence. [78] Truong *et al*., 2007 from Vietnam reported IC_{50} for DPPH radicalscavenging activity was 46.0 from leaves and 24.0 mg/mL from inflorescence. [79] Vit *et al*., 2008, from Europe reported IC_{50} for DPPH radical-scavenging activity was higher in leaves and average activity in inflorescence. [80] Dall'Acqua *et al*., 2007, reported from Sardinia observed the IC_{50} for DPPH radical-scavenging activity in whole plant and confirmed the higher activity in areal leaves than in inflorescence and root part. [81] Ebrahmzadah *et al*., 2010 from Iran reported IC_{50} for DPPH radical-scavenging activity was 33.0 from leaves and 24.3 mg/mL from root have been demonstrated to have the antioxidant activity in tested models. The roots of *E. foetidum* were shown to have highly antioxidant activity toward the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical in a TLC autographic assay. By further bioassay fractionation, compounds R-(+)-rosmarinic acid, R-(+)-3'-O--D-glucopyranosyl rosmarinic acid, and chlorogenic acid were found to respond for the activity. Related to the activity of ascorbic acid, the antioxidant activity of R-(+)-rosmarinic acid

was almost onefold higher than R-(+)-3'-O--D-glucopyranosyl rosmarinic acid, and like caffeic acid the results are consistent with published reports indicating that the position and/or the number of glycosyl groups present in the molecule plays a significant part in the antioxidant activity [82]. *E. foetidum* at flowering stage, which was found recently as a new cultivated vegetable plant in home gardens in northern Iran, were investigated for their antioxidant activities employing six *in vitro* assay systems. Extracts exhibited different levels of antioxidant activity in all the models studied. Extracts showed very good scavenging activity of H_2O_2 with IC_{50} of 25.5 mg/mL for leaves and 177.2 mg/mL for inflorescence, respectively; IC_{50} for DPPH radical-scavenging activity was 0.15 for leaves and 0.39 mg/mL for inflorescence; leaves extract exhibited better Fe^{2+} chelating ability (IC_{50} = 0.25 mg/mL) than that of EDTA (IC_{50} = 18 µg/mL) [81]. [82] LeClaire, *et al*., 2005 reported the leaves and inflorescence extracts and inflorescence stage showed stronger NO scavenging and peroxidation inhibition, and very less scavenging activity of H_2O_2, reducing powers and Fe^{2+} chelating ability than leaves. *Eryngium* exhibited weak radical scavenging activity (IC_{50} = 0.28 mg/mL), low total phenol content (16.4 mg/g), as well as relatively strong total antioxidant activities (from 32.7 to 48.6 mg/g) [83]. Furthermore the antioxidant properties have been recorded for the first time in the essential oil of *E. Foetidum* [55]. [81] Ebrahimzadeh, *et al*., 2006 showed promising antioxidant properties by significant quenching impact on the extent of lipid peroxidation and activities of both enzymatic and non-enzymatic anti-oxidants in plasma and tissues were also studied. [51] Leclercq, *et al*., 1992, reported that the number of glycosyl groups present in the molecule plays a significant role in antioxidant activity in essential oil extracted from leaves. Essential oil exhibited different levels of antioxidant activity in all the assays studied. Extracts exhibited high scavenging activity of antioxidant with IC_{50} with 22.00 µg/ml respectively, against standard ascorbic acid IC_{50} of 19.07µg/ml indicating high antioxidant property in all the samples tested. This proves the presence of essential oil closely followed by the saponin acts as a strong antioxidant property. [84] Joergen *et al*., 1992 also reported a good antioxidant activity of *E. foetidum* from flowers, aerial part and root using the same assay systems. The aerial part extracts showed stronger nitric acid scavenging and peroxidation inhibition, and very less scavenging activity of H_2O_2, reducing powers and Fe^{2+} chelating ability than flower and root antioxidant activities.

Anti-Inflammatory Activities:

Ethanol extracts obtained from the aerial part of leaves and aerial parts of *E. foetidum* are used as folk remedy worldwide for the treatment of various inflammatory disorders. [10] Pala-Paul, *et al*., 2008 reported anti-inflammatory activity by screening the traditional Mediterranean diet, *E. foetidum* decreased LPS-stimulated iNOS mRNA level and also showed remarkable anti-inflammatory activities. [61] Shavandi, *et al*., 2012, showed aerial parts were found to possess most promising activities without any apparent gastric damage in mice model studies. More detailed research showed the anti-inflammatory effect of *E. foetidum* produces sub-alkaline fraction was showed by [12]. The hexane extracts of leaves of *E. foetidum* reduces paw edema, by 12-0-tetradecanoylphorbol acetate (TPA) in the mice with acute [22]. [39] Garcia *et al*., 1999 reported that the leaves rich in stigmasterol (95%) showed topical anti-inflammatory activity on chronic and acute inflammation in animal models. Although stigmasterol exhibits significant topical anti-inflammatory activity, by itself it could not account for the overall effects observed for the total phytosterols [85]. The decoction when given orally to rodents in doses of 250 and 500 mg/kg, was also found to inhibit carrageenan-induced edema in the paws and 12-O-tetradecanoylphor-bol acetateinduced edema in the ears [47]. In order to find out the compounds possibly responsible for the anti-inflammatory activity of *E. foetidum*, composition of the hexane extract from the leaves was subjected to GC and GC-MS analysis [39]. Hereby, α-cholesterol, brassicasterol, campesterol, stigmasterol, clerosterol, β-sitosterol, Δ_5-avenasterol, Δ_{5}-24-stigmastadienol and Δ_7-avenasterol were detected in the extract. These results indicate anti-inflammatory and analgesic activity, results to claim in the traditional folklore of use in the treatment of asthma and rheumatism [86, 61].

Anti-diabetic activity

Many reports on *E. foetidum* mention on the treatment of diabetes [57] [88] Mahabir and Gulliford, 1997). According to [89] Mai *et al*. 2007, a perfect anti-diabetic compound from any source

should possess both hypoglycemic and antioxidant properties. Preliminary evaluation of the blood glucose lowering methanolic effects of *E. foetidum* (at 351 mg/kg and 176 mg/kg) on three animal models (normoglycaemic rats, streptozotocin-induced diabetic rats and normal rats) subjected to the oral glucose-tolerance test, revealed that oral dose of the leaf extract showed significant reduction in the level of glucose of the models tested [90]. The study reveals that methanolic extract of the leaves efficiently inhibits alpha glucosidase enzymes *in vitro* in dose dependent manner. Plant attributed to the intestinal alpha glucosidase inhibitory activity, was evaluated for the usage of the leaves of *E. foetidum* as an anti-diabetic agent [57].

Conclusion

Research studies have confirmed the anthelmintic, anti-convulsant and antiinflammatory properties of the leaf extract of *E. foetidum*. Other reports have mentioned the selective activity of plant extracts against certain plant pathogenic bacteria, thereby revealing a possible role as a pest control agent in the agriculture industry. The reported activity against *Salmonella typhi* is probably related to its ethno medicinal use for stomach ache. Further investigations are needed to fully explore this property. However, the extensive use of the raw plants used by ancient tribes for various pains such as headaches, stomach ache, earache and menstrual pain, is notable. Its ethnomedicinal uses are numerous however only a few properties have been studied and data for clinical trials in human is severely lacking. The technology needed to produce the plant in mass is already in use in regions where it is grown for exportation. Analyses of the chemical constituents have focused mainly on the essential oils. These facts taken together make this plant a very suitable candidate for exploration studies for new pharmaceutical agents.

Conflict of interest statement

We declare that we have no conflict of interest

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