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A REVIEW ON *ERODIUM CICUTARIUM*: A POTENTIAL MEDICINAL PLANT

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Abstract:

Phytochemical analysis showed that Erodium cicutarium contained Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine,alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C , and wide range of essential and volatile oils. Erodium cicutarium possessed many pharmacological effects included antibacterial, antifungal, antiviral, interferon induction, antioxidant, antiinflammatory, analgesic, antiproliferative effects and affected smooth and cardiac muscles tones. This review discussed the chemical constituents and pharmacological effects of Erodium cicutarium.

Keywords: *Erodium cicutarium, contents, pharmacology*

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INTRODUCTION:

A large and increasing number of patients in the world use medicinal plants and herbs for health purpose. Therefore, scientific scrutiny of their therapeutic potential, biological properties, and safety will be useful in making wise decisions about their use. Recent reviews showed that plants produce many secondary metabolites which are bio-synthetically derived from primary metabolites and constitute an important source of many drugs [1-30]. Phytochemical analysis showed that *Erodium cicutarium* contained Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine,alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C , and wide range of essential and volatile oils. *Erodium cicutarium* possessed many pharmacological effects included antibacterial, antifungal, antiviral, interferon induction, antioxidant, antiinflammatory, analgesic, antiproliferative effects and affected smooth and cardiac muscles tones. This paper will discuss the chemical constituents and pharmacological effects of *Erodium cicutarium.*

Synonyms:

Erodium albidum Picard, *Erodium allotrichum* Steud. ex A. Rich., *Erodium alsiniflorum* Delile, *Erodium ambiguum* Pomel, *Erodium arenarium* Jord., *Erodium atomarium* Delile ex Godr., *Erodium boraeanum* Jord., *Erodium carneum* Jord., *Erodium chaerophyllum* (Cav.) Steud. ex Coss., *Erodium chaerophyllum* Steud., *Erodium cicutarium* var. arenicola (Steud.) Speg., *Erodium cicutarium* f. chaerophyllum (Cav.) DC., *Erodium cicutarium* subsp. dunense Andreas, *Erodium cicutarium* var. immaculatum W. D. J. Koch, *Erodium cicutarium* subsp. ontigolanum Guitt., *Erodium cicutarium* var. triviale Trautv., *Erodium cicutarium* subsp. zairae A. P. Khokhr., *Erodium cicutifolium* Salisb., *Erodium commixtum* Jord. ex F. W. Schultz, *Erodium danicum* K. Larsen, *Erodium dissectum* Rouy, *Erodium filicinum* Pomel, *Erodium glutinosum* Dumort., *Erodium himalayanum* Royle, *Erodium hirsutum* Schur, *Erodium hirsutum* Schur, *Erodium immaculatum* (W. D. J. Koch) P. Fourn., *Erodium maculatum* Salzm. ex C. Presl, *Erodium melanostigma* Mart., *Erodium millefolium* Willd. ex Kunth, *Erodium minutiflorum* Godr., *Erodium moranense* Willd. ex Kunth, *Erodium pallidiflorum* Jord., *Erodium petroselinum* L'Hér. ex DC., *Erodium pimpinellifolium* (Moench) Sibth, *Erodium praetermissum* Jord. ex Boreau, *Erodium triviale* Jord., *Erodium sabulicolum* Jord. ex Nyman, *Erodium subalbidum* Jord. and *Erodium verbenifolium* Delile [31].

Taxonomic classification:

Kingdom: Plantae, **Subkingdom**: Viridiplantae, **Infrakingdom**: Streptophyta, **Superdivision**: Embryophyta, **Division**: Tracheophyta, **Subdivision**: Spermatophytina, **Class**: Magnoliopsida, **Superorder**: Rosanae; **Order**: Geraniales, **Family**: Geraniaceae, **Genus**: *Erodium*, **Species**: *Erodium cicutarium* [32-33].

Common names:

Arabic: dahmiyet el-ghazal, dardar, bakhatri; **English**: alfilaria, common crowfoot, common erodium, common heron's-bill, common stork's-bill, heron's-bill, red-stem filaree, stork's-bill [32].

Distribution:

Erodium cicutarium isdistributed in **Africa** (Algeria, Egypt, Libya, Morocco and Tunisia); **Asia** (Kuwait, Iraq, Palestine, Jordan, Lebanon, Syria, Turkey, Afghanistan, Iran, Armenia, Azerbaijan, Georgia, Russian Federation, China, India, Nepal, Pakistan, Taiwan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan); **Europe** (Belarus, Estonia, Latvia, Lithuania, Moldova, Austria, Belgium, Czech, Germany, Hungary, Netherlands, Poland, Slovakia, Switzerland, Denmark, Finland, Ireland, Norway, Sweden, United Kingdom, Albania, Bulgaria, Croatia, Greece, Romania, Serbia, Slovenia, France, Portugal and Spain) and it is cultivated in **South** and **North America** [32].

Description:

Annuals 10-15(-40) cm tall. Stems numerous, erect to decumbent. Stipules triangular-lanceolate, 2-6 mm. Leaves opposite or alternate; leaf blade triangular-lanceolate to oblong-lanceolate, 5-18 cm, pinnately divided to pinnately cleft, 5-12-lobed with basal ones more deeply incised, both surfaces appressed pilose. Pseudoumbels conspicuously longer than leaves, with (2 or)3-10 hermaphrodite flowers; peduncle with glandular and nonglandular trichomes. Pedicel 0.8-1.7 cm. Sepals ovate, 3-6 mm, glandular and hirsute, apex acute. Petals uniformly purple or 2 with a basal black spot, obovate, 5-12 mm. Mericarp 3-7 mm, with apical pit, with or without ridges or furrows; awn not plumose [34-35].

Traditional uses

The whole plant was used as astringent and haemostatic in uterine and other bleeding [36-37] and as abortifacient [38-39]. Extracts of the plant were also used in traditional medicine as antidiarrheic, diuretic, stomachic and antihemorrhageic drugs [40]. The root and leaves were eaten by nursing mothers to increase the flow of milk. Externally, the plant has been used as a wash on animal bites and skin infections. A poultice of the chewed root was applied to sores and rashes. A tea made from the leaves was

used as diaphoretic and diuretic. An infusion was used in the treatment of typhoid fever. The leaves were soaked in bath water for the treatment of rheumatism. A poultice of the seeds was applied to gouty typhus [36].

Chemical constituents:

Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine,alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C were identified in *Erodium cicutarium* extracts [41].

The essential oils of *Erodium cicutarium* were examined by GC/MS. The results showed that the major components were isomenthone (11.2%), citronellol (15.4%), geraniol (16.7%) and methyl eugenol (10.6%) [42].

Essential oils from entire plants and leaves and stems of *Erodium cicutarium* were obtained by hydrodistillation and analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC/MS). The essential oils were of a very similar chemical composition and consisted mainly of aliphatic compounds and their derivatives. Fatty acids and fatty acid derived compounds were the most common, 51.3% (entire plants) and 60.1% (leaves and stems), followed by carotenoid derived compounds, 12.6% (entire plants) and 20.2% (leaves and stems), and then terpenoids, 14.9% (entire plants) and 14.2% (leaves and stems). The main constituents in the oils were hexadecanoic acid, 22.8% (leaves and stems) and 35.9% (entire plants) and hexahydrofarnesyl acetone, 10.8% (leaves and stems) and 11.6% (entire plants) [43].

All Erodium species contained a small amount of volatiles (0.01–0.06 mass %). Essential oils of *Erodium cicutarium* contained fatty acids and fatty acid derived compounds: 63.8%, carotenoid derived compounds: 18.5%, terpenoids: 13.1%, monoterpenoids: 1.3%, monoterpene hydrocarbons: trace, oxygenated monoterpenes: 1.3%, sesquiterpenoids: 5.9%, sesquiterpene hydrocarbons: 0.9%, oxygenated sesquiterpenes: 5.0%, diterpenoids: 5.9% and oxygenated diterpenes: 5.9%. However, 162 compounds were identified in the essential oils of flowers, leaves, stems, and roots samples of *Erodium cicutarium*. These compounds included (%): Octane: trace, Hexanal: 0.2, Benzaldehyde: 0.1, Hexanoic acid: 0.1, 2-Pentylfuran: trace, 2,4,6-Trimethylpyridine: trace, Decane: trace, Octanal: 0.1, p-Cymene: trace, *β*-Phellandrene: trace, Benzyl alcohol: trace, Lavender lactone: trace, Phenyl acetaldehyde: 0.1, Heptanoic acid: trace, 1-Octanol: trace, cis-Linalool oxide (furanoid): 0.1, trans-Linalool oxide (furanoid): 0.1, 2-Nonanone : trace, p-Cymenene: trace, Linalool: 0.3, Nonanal: 0.2, trans-Pinocarveol: 0.1, Camphor: 0.1, Benzoic acid: 0.5, Octanoic acid: 0.1, 1-Nonanol: 0.1, cis-Linalool oxide (pyranoid): trace, trans-Linalool oxide (pyranoid): trace, Terpinen-4-ol: 0.2, m-Cymen-8-ol: trace, p-Cymen-8-ol: 0.2, (3E)-2,6-Dimethyl-3,7-octadiene-2,6-diol: trace, 1-Dodecene: trace, Cryptone: trace, *α*-Terpineol: trace, Dodecane: trace, Myrtenol : trace , Decanal: 0.1, Verbenone: trace, *β*-Cyclocitral: trace, exo-2-Hydroxy-1,8-cineole: trace, Bornyl formate: trace, Phenylacetic acid: 0.1, Nonanoic acid: 0.4, 2,6-Dimethyl-1,7-octadien-3,6-diol: trace, 3-Methyldodecane: trace, cis-p-Menth-2-en-1,8-diol: trace, Bornyl acetate: trace, Thymol: 0.1, Tridecane: trace, Carvacrol: trace, Undecanal: 0.1, Vinylguajacol: trace, (E, Z)-2,4-Decadienal: trace, *δ*-Elemene: 0.1, Eugenol: trace, Decanoic acid: 0.1, 3-Methyltridecane: trace, Farnesane: trace, *β*-Bourbonene: 0.1, *β*-Elemene: trace, Tetradecane: 0.2, 6,10-Dimethylundecan-2-one (tetrahydrogeranyl acetone): 0.2, Dodecanal: trace, *γ*-Elemene: 0.3, 2,6-Dimethyl-2,6-undecadien-10-one (geranyl acetone): 0.8, 5-Methyltetradecane: trace, *α*-Humulene: trace, Homofarnesane 0.5, Undecanoic acid: trace, 1-Dodecanol: 0.1, *γ*-Gurjunene: trace, *γ*-Curcumene: trace, *γ*-Muurolene: 0.1, *α*-Curcumene: trace, Germacrene: trace, trans-*β*-Ionone-5,6-epoxide: 0.1, Pentadecane: 0.2, *α*-Muurolene: trace, Tridecanal: 0.3, Dibenzofuran: trace, *γ*-Cadinene: trace, 3,4-Dimethyl-5-pentyl-2(5H)-furanone (dihydrobovolide): 0.1, trans-Calamenene: 0.1, Dihydroactinidiolide: 0.1, *α*-Calacorene: 0.1, Salviadienol: trace, Dodecanoic acid: 0.3, 11-nor-Bourbonan-1-one: trace, *γ*-Calacorene: 0.1, (Z)-3-Hexenyl benzoate: trace, Spathulenol: 0.5, Caryophyllene oxide: 2.1, Hexadecane: 0.2, Viridiflorol: 0.1, Tetradecanal: 0.4, Humulenepoxide: 0.1, nor-Copaanone: 0.1, Muurola-4,10(14)-dien-1*β*-ol: trace, Cubenol: 0.1, Caryophylla-4(12),8(13)-dien-5*α*-ol: trace, Caryophylla-4(12),8(13)-dien-5*β*-ol: trace, epi-*α*-Muurolol: 0.5, *α*-Muurolol: 0.1, *α*-Cadinol: 1.1, Tridecanoic acid: 0.1, 2-Methylhexadecane: trace, 1-Tetradecanol: trace, Cadalene: trace, Amorpha-4,9-dien-2-ol 0.3, Heptadecane: 0.2, Pristane: 0.3, 10-nor-Calamenen-10-one: trace, Pentadecanal: 0.3, Methyl tetradecanoate: trace, 4-Methylheptadecane: trace, Tetradecanoic acid: 3.5 , Benzyl benzoate: 0.5, 3-Methylheptadecane: trace, 1-Pentadecanol: 0.1, Phenanthrene: 0.4, *γ*-Tridecalactone: trace, Octadecane: 0.1, Phytane: 0.1, Hexadecanal: 0.3, Neophytadiene (isomer II): 1.1, 6,10,14-Trimethyl pentadecan-2-one (hexahydrofarnesyl acetone): 15.5, Pentadecanoic acid: 0.9, Benzyl salicylate: trace, 1-Hexadecanol: 0.1, Nonadecane: 0.1, 5-(4,8-Dimethylnonyl)-5-methyldihydro-2(3H)-furanone: trace, Methyl hexadecanoate: 0.1, Isophytol: 0.3, Hexadecanoic acid: 38.3, Ethyl hexadecanoate: trace, Eicosane: 0.2, Octadecanal: 0.3, Heptadecanoic acid: 1.0, Manool: 1.5, 1-Octadecanol: 0.2, Heneicosane: 1.6, *γ*-Hexadecalactone: trace, (E)-Phytol: 2.6, (Z, Z)-9,12-Octadecadienoic acid (linoleic acid): 0.1, (Z)-9-Octadecenoic acid (oleic acid): 0.8, Octadecanoic acid: 2.3, Docosane: 0.2, (E)-Phytyl acetate: 1.8, Eicosanal: 0.1, Tricosane: 0.6, 5-Methyl-5-(4,8,12-

trimethyltridecyl)dihydro-2(3H)-furanone: 0.6, Tetracosane: 1.2, 1-Docosanol: 0.1, Pentacosane: 4.5, Hexacosane: 2.1, Heptacosane: 0.8, Octacosane: 0.1, Nonacosane: 0.1 and Triacontane: trace [44].

The total polyphenol content of the dry raw material of *Erodium cicutarium* was 3.41%; flavonoids (calculated as quercetin) represented 0.45% and tannins 0.78% [45].

The major phenolic acids and depsides in methanol extracts extracted from *Erodium cicutarium* were gallic acid 12.40, protocatechuic acid 3.93, gallic acid methyl ester 18.38, brevifolin 25.95 and ellagic acid 11.88 mg per gram of dry weight [46].

A depside, erodiol, geraniin, didehydrogeraniin, corilagin, (–) 3-*O*-galloylshikimic acid, methyl gallate 3-*O*-β -D-glucopyranoside, rutin, hyperin, quercetin 3- *O*-(6"-*O*-galloyl)-β -D-galactopyranoside, isoquercitrin and simple phenolic acids were isolated from the aerial parts of *Erodium cicutarium* [40].

A field study was carried out to determine the effects of different levels of soil water availability on concentrations and partitioning of sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg) in various organs of *Erodium cicutarium*. The ground plant parts and roots showed lower or similar, but not higher, Na concentrations under water stress than under irrigated conditions. Concentrations of K, Ca, and Mg of the ground plant parts and roots were greater under water stress than under irrigated conditions. The plant parts had lower Na and a greater K concentration than roots. Leaves and roots had similar Mg concentrations. However, concentrations of this nutrient were greater or similar in roots than in leaves in *Erodium cicutarium*, and those of Ca were greater in leaves than roots. Leaves and/or stems had greater Ca concentrations than fruits under all water levels. The lowest concentrations of Na, Ca, K, and Mg among plant parts were generally found in flowers [47].

Pharmacological effects:

Antibacterial and antifungal effects:

The essential oils of *Erodium cicutarium* were tested against Gram positive *Staphylococcus aureus* (ATCC 27853), *Staphylococcus aureus* (clinical isolate), *Clostridium perfringens* (ATCC 19404), *Bacillus subtilis* (ATCC 6633), Gram negative *Escherichia coli* (ATCC 25922), *Escherichia coli* (clinical isolate), *Klebsiella pneumoniae* (clinical isolate), *Pseudomonas aeruginosa* (ATCC 25923), and yeast *Candida albicans* (ATCC 10231). MIC of *Erodium cicutarium* against *P. aeruginosa* was 0.312 mg/ml, Escherichia coli (ATCC 25922) 0.625 mg/ml, *Escherichia coli* (clinical isolate) 2.5 mg/ml, *K. pneumoniae* 1.25 mg/ml, *Staphylococcus aureus* (ATCC 27853) 0.312 mg/ml, *Staphylococcus aureus* (clinical isolate) 2.5 mg/ml, *C. perfringens* 0.312 mg/ml, *B. subtilis* 0.625 mg/ml, *P. chrysogenum* 0.156 mg/ml, *A. restrictus* 0.078 mg/ml, *A. chrysogenum* 0.156 mg/ml, *A. fumigatus* 0.156 mg/ml, and *C. albicans* 0.325 mg/ml [44].

Antiviral and interferon inducing effects:

Extracts from *Erodium cicutarium* were tested for antiviral and interferon inducing properties. Both water extract and methanol extract as well as its fractions exerted antiviral effect in relation to myxoviruses, herpes virus type 1, vesicular stomatitis and vaccinia virus. None of these extracts did induce interferon in a suspension of human leukocytes [48].

Methanol extract from *Erodium cicutarium* induced interferon in a suspension of human leukocytes or in the cutaneo-muscular tissue of human embryo. It exerted stimulatory effect on the synthesis of interferon induced with Newcastle disease virus in cell cultures. The stimulation occurred irrespective of the time of methanol extract administration (before or after viral inducer). In the *in vivo* experiments, methanol extract injected intravenously induced interferon in mice. When given 24 h prior to Newcastle virus, it increased the titer of induced interferon determined in the animal serum collected 6 h after the virus injection. In the experimental viral infection in mice, the replication of influenza A virus in the lung tissue of infected animals was inhibited only when the mice were treated with methanol extract 24 and 48 h after infection with the virus [49].

Antioxidant effect:

Extracts from *Erodium cicutarium* extracts were tested for their antioxidative properties using Fe^{2+}-induced triglyceride oxidation test. Hydrophobic fractions such as petroleum ether, benzene and chloroform extracts as well as hydrophilic fractions (water and ethyl acetate) possessed antioxidative effect. Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose) amino acids (glycine, alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C were identified in *Erodium cicutarium* extracts. Standard samples of all these substances were tested for their antioxidative activity. Only polyphenolic compounds (tannin, gallic acid, (+)-catechin and vitamin C exhibited strong antioxidative properties [41].

Methanol extracts of nine species of geraniaceae including *Erodium cicutarium* were studied for their antioxidant properties using DPPH (1,1-diphenyl-2-picryl hydrazyl) radical assay. Methanol extract of *Erodium cicutarium* exhibited considerable free radical scavenging activity and its IC_{50} values was below 50 µg/ml [50].

The methanol extract contained quercetin, kaempferol, myricetin, their mono- and di-glycosidic derivatives, and free polyphenolic acids. Low concentrations of the extract stimulated, and high concentrations inhibited, the free radical activity of human granulocytes *in vitro* [45].

Effect on smooth and cardiac muscles:
Hexane extract of *Erodium cicutarium* at a concentration of 0.15 mg/ml increased the tone of the guinea pig ileum preparation and reduced the strength of the contractions following field stimulation. All extracts prepared from *Erodium cicutarium* possessed spasmogenic action on isolated uterus preparation of the rat. The methanol extract of *Erodium cicutarium* at a concentration of 1.3 mg/ml in the preparation produced regular monophasic contractions of the quiescent uterus, which ceased immediately when the tissue was washed. All extracts prepared from *Erodium cicutarium* increased tension in the isolated diaphragm muscle without affecting twitch strength. The addition of extracts of *Erodium cicutarium* to the Kreb's solution perfusing isolated heart from rabbit, they produced a negative ionotropic action. Organic extracts (hexane and methanol) showed greater activity on smooth and cardiac muscles than water extracts [48-49].

Antiproliferative effect:
In studying of antiproliferative effect of ethanolic extract of twenty-six plant species from the native flora used in Bolivian folk medicine, on colon cancer cells (Caco-2), the results indicated that ethanolic leaves extracts of *Erodium cicutarium* possessed significant antiproliferative activity. It caused 10% proliferation inhibition at 100 µg/ml [51].

Antiinflammatory and analgesic effects:
A 70% ethyl alcohol thick extract from equal amounts of the aerial parts of *Geranium sanguineum*, *Astragalus glycyphyllos*, *Erodium cicutarium* and *Vincetoxicum officinalis* was prepared to study its anti-inflammatory and analgesic effects. The anti-inflammatory effect was conducted by the method of carageenan-induced paw edema, while analgesic effect was determined by hot/ cold plate and Randall & Selitto test (Analgesy-meter). Rats treated with the extract at dose of (1 and 2 g/kg bw), showed no statistically significant anti-inflammatory effects. The extract also showed no reliable analgesic effect (excluding the dose of 1g/kg bw, 1st hour, p = 0.031). However, a reliable analgesic effect was recorded with the using of 2 g/kg bw of the extract on the 2nd and 3rd hour (p = 0.037, p = 0.022). In repeated dose of the extract, the treated animals showed statistically reliable analgesic effect at the dose of 1g/kg bw, on the 1st, 2nd and 3rd hour (p = 0.024, p = 0.029, p = 0.021) [52].

Other effects:
Extracts of *Erodium cicutarium* of the phenolic dilactone ellagic acid inhibited the growth of the tobacco budworm, *Heliothis virescens*. Extracts from *Erodium cicutarium* plants, with paraffin oil added as an adjuvant, had some effect on controlling the Colorado potato beetle (*Leptinotarsa decemlineata* Say) by eliminating beetle feeding and development. The alcohol and water extracts of *Erodium cicutarium* possessed moderate effects in reducing body mass and caterpillar feeding of the cabbage butterfly, *Pieris brassicae* [53-55].

CONCLUSION:
This review discuss the chemical constituent, pharmacological and therapeutic effects of *Erodium cicutarium* as promising herbal drug because of its safety and effectiveness.

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