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Review

Phytochemistry and pharmacological properties of *Equisetum arvense* L.

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***Equisetum arvense* L. is known as Horsetail. *E. arvense* extracts are important areas in drug development with numerous pharmacological activities in many countries. For a long time, *E. arvense* has been used in traditional medicines for the treatment of brittle fingernails, loss of hair and for rheumatic diseases. *E. arvense* has recently been shown to have antibacterial, antifungal, antioxidant, analgesic, anti-inflammatory, antidiabetic, antitumor, cytotoxic and anticonvulsant activities. Apigenin, luteolin, equisetumoside A, equisetumoside B and equisetumoside C, nicotine, palustrine and palustrinine are phytochemical compounds which are reported from this plant. Due to the easy collection of the plant and being widespread and also remarkable biological activities, this plant has become medicine in many countries. This article presents comprehensive analyzed information on the botanical, chemical and pharmacological aspects of *E. arvense*.**

Key words: *Equisetum arvense*, Equisetaceae, pharmacology, phytochemistry.

INTRODUCTION

Equisetum arvense L. commonly known as Horsetail is a bushy perennial herb, originally native to northern hemisphere. *Equisetum* species is widely distributed throughout Canada, USA except the southeast, Europe and Asia south to Turkey, Iran, the Himalayas, across China (except the southeastern part), Korea and Japan (Gleason and Cronquist, 1991). *E. arvense* belongs to Equisetaceae family in the order of Equisetales that contains just only one living genus. The genus *Equisetum* consists of 30 species of rush like, conspicuously jointed, perennial herbs (Sandhu et al., 2010). Horsetail is a strange-looking sort of plant with creeping, string like rootstock and roots at the nodes that produce numerous hollow stems. Two markedly different types; the sterile stems (Figure 1) tend to be much taller and bushier, with the jointed segments being around one inch long with a diameter of about 1/20th of an inch. These segments contain one set of whorled, slender, erect branches each. Some stems can have as many as 20 segments and be as tall as 2 to 24 inches. The fertile stems tend to be half as tall as the sterile stems and also tend to be more succulent. Fertile stems (Figure 2) unbranched, appear in early spring, usually thick and succulent, brownish to whitish, 10 to 30 cm tall. Sterile stems bottlebrush-like (many whorls of slender branches), appear as fertile stalks wither 1-several in clusters, 10 to 50 cm tall; slender, green, 10 to 12 ridged, minutely roughened; branches simple, first branch segment longer than adjacent stem sheath (Sandhu et al., 2010).

E. arvense has been known as “Dom Asb” in Iran and distributed in northern and northwestern regions of Iran (Soleimani et al., 2007).

For a long time, *E. arvense* has been used as a folklore medicine for treatment of various conditions such as tuberculosis, as a catarrh in the kidney and bladder regions, as a hematostatic for profuse menstruation, nasal, pulmonary and gastric hemorrhages, for brittle fingernails and loss of hair, for rheumatic diseases, gout, poorly healing wounds and ulcers, swelling and fractures and for frostbite (Sandhu et al., 2010). Horsetail can produce toxic effects on its prolonged use. Silicates produce digestive problems, especially when used for long. Alkaloids although do not appear in strong concentrations, a prolonged use, can take place by accumulating them in the organism which may facilitate premature childbirth, nervous disorders, headaches, loss of appetite, swallowing problems, etc. These intoxications

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Figure 1. Sterile stems of *E. arvense*.

Figure 2. Fertile stems of *E. arvense*.

force to a treatment that restores the thiamine deficiency, although in the case of the animals, they are no longer recoverable in many occasions (Sandhu et al., 2010).

A number of chemical constituents such as alkaloids, triterpenoids, flavonoids, phenolics and tanins have been isolated from different parts of the plant (Cetojevic-Simin et al., 2010; Mojab et al., 2003).

From current pharmaceutical studies, additional pharmaceutical applications of *E. arvense* have revealed antioxidant, anti-inflammatory, antidiabetic, antibacterial, antifungal, anticonvulsant and anticancer (Cetojevic-Simin et al., 2010; Dos Santos et al., 2005; Yamamoto et al., 2004; Sandhu et al., 2010) effects among others.

Since review and systemic analysis of chemistry, pharmacology and clinical properties of *E. arvense* have not been reported; we prompted to provide the currently available information on traditional and local knowledge, ethno biological and ethno medicinal issues, identification of pharmacologically important molecules and pharmacological studies on this useful plant. The aim of this article is to introduce *E. arvense* as a potent medicinal plant by highlighting its traditional applications as well as the recent findings for novel pharmacological and clinical applications.

Potential of *E. arvense* in phytotherapies

E. arvense is used in traditional medicine to treat various diseases such as tuberculosis, kidney disorders and bladder disease. It is used as a haemostatic for profuse menstruation, nasal, pulmonary and gastric hemorrhages, for brittle finger nails and loss of hair, for rheumatic diseases, gout, poorly healing wounds and ulcers, swelling and fractures and for frostbite (Sandhu et al., 2010). Although, the antioxidant, anti-inflammatory, analgesic, antibacterial, antifungal, antitumor and neuroprotective effects of *E. arvense* extracts have been well documented, so far the therapeutic potential has not been exploited by the western countries (Cetojevic-Simin et al., 2010; Dos Santos et al., 2005; Yamamoto et al., 2004; Sandhu et al., 2010). In recent years, accumulating evidence indicated that not only is *E. arvense* important in treating inflammation and pain, but that it also contains anticonvulsant, antibacterial, antifungal, anti haemorrhagy, astringent, diuretic, hepatoprotective, antiviral (HIV), vasorelaxant, cardioprotective and vulnerary effects (Cetojevic-Simin et al., 2010; Dos Santos et al., 2005; Yamamoto et al., 2004; Sandhu et al., 2010).

Chemical composition

The commonly known phytochemical compounds from *E. arvense* are alkaloids, phytosterols, tannin, triterpenoids and phenolics such as flavonoids, styrylpyrones and phenolic acids (Cetojevic-Simin et al., 2010; Mojab et al., 2003).

Styrylpyrones accumulate in rhizomes of sporophytes and gametophytes of *E. arvense* as major constitutive metabolites. In these organs, no flavonoids could be detected. In green sprouts, styrylpyrone accumulation is only detected as a local response to mechanical wounding or microbial attack, and flavonoids are accumulated as major polyketide metabolites (Beckert et al., 1997). Rhizomes also contain 3'-deoxyequisetumpyrone (3, 4-hydroxy-6-(4'-hydroxy-D-styryl)-2-pyrone-3-O- -D-glucopyranoside) and 4'-Omethylequisetumpyrone (3,4-hydroxy-6-(3'-hydroxy-4'-methoxy-Estyryl)-2-pyrone-3-O-D-glucopyranoside). Vegetative stems contain equisetumpyrone (Veit et al., 1995; Beckert et al., 1997; Veit et al., 1993).

Sterile stems reported to contain 0.3 to 0.9% of total flavonoids. Various flavonoids present are kaempferol 3-Osophoroside-7-O-glucoside, kaempferol 3-O-(6”-O malonylglucoside)-7-O-glucoside. Kaempferol 3-O-sophoroside, quercetin3-O-glucoside, apigenin, apigenin 5-O-glucoside, luteolin, luteolin 5-O-glucoside, genkwanin 5-O-glucoside and isoquercitrin (Oh et al., 2004; Cornet et al., 1991; PDR, 2000; Pietta et al., 1991; Suzuki and Homma, 1997).

Phenolic glycosides such as equisetumoside A, equisetumoside B and equisetumoside C have been identified in the fertile sprouts (Chang et al., 2001). Onitin and onitin-9-O-glucoside are phenolic petrosins isolated from this plant (Oh et al., 2004).

Barren sprouts from Asia and North America *E. arvense* contain flavone 5-glucosides and their malonyl esters, whereas European ones are free from these compounds. Both types contain quercetin 3-*O*-β-D-glucopyranoside, and its malonyl ester. Quercetin 3-*O*-sophoroside, genkwanin 4′-*O*-β-D-glucopyranoside and protogenkwanin 4′-*O*-β-D-glucopyranoside are only found in European ones (Veit et al., 1990).

Di-*E*-caffeoyl-*meso*-tartaric acid was isolated from the methanolic extract of the barren sprouts of *E. arvense* as the main hydroxycinnamic acid derivative. It is a marker compound for *E. arvense* and its concentration over a two year growth period is reported (Veit et al., 1991).

Alkaloids such as nicotine, palustrine and palustrinine also reported from this plant (Cetojevic-Simin et al., 2010).

Isobauerenol, taraxerol, germanicol, ursolic acid, oleanolic acid and betulinic acid are triterpenoids isolated from the sterile stems (Ganeva et al., 2001).

Sterile stems also rich in phytosterols such as cholesterol, epicholestanol, 24-methylenecholesterol, isofucosterol (5.9%), campesterol (32.9%) and β-Sitosterol (60%) (Ganeva et al., 2001; Takatsuto and Abe, 1992; Monte et al., 2001).

Neuroprotective effects

The hydroalcoholic extract of *E. arvense* stem has shown

an antinociceptive property, which is not related to the opioid system (Do Monte et al., 2004). Chronic administration of the hydroalcoholic extract from stems of *E. arvense* improves the cognitive deficits in aged rats, and this effect can be due, at least in part, to its antioxidant action (Dos Santos et al., 2005).

E. arvense hydroalcoholic extract presented anticonvulsant and sedative effects. The doses 200 and 400 mg/kg of the extract have shown a significant activity on the open-field, enhanced the number of falls in the rota-rod reducing the time of permanence in the bar and increased the sleeping time (46 and 74%) in the barbiturate-induced sleeping time. In the pentylenetetrazole-seizure, the plant extract increased the first convulsion latency, diminished the severity of convulsions, reduced the percentage of animals which developed convulsion (50 and 25%) and protected animals from death. On the contrary, in the elevated plus maze, the doses 50, 100 and 150 mg/kg did not affect the evaluated parameters. These effects may be related to the presence of tannins, saponins, sterols and flavonoids detected in this plant (Dos Santos et al., 2005).

Antioxidant activity

An antioxidant is defined as 'any substance that, when present at low concentrations compared to those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate' (Rhee et al., 2009; Wiseman et al., 1997; Mates et al., 1999). Antioxidants are of interest to biologists and clinicians because they help to protect the human body against damages induced by reactive free radicals generated in atherosclerosis, ischemic heart disease, cancer, Alzheimer's disease, Parkinson's disease and even in aging process (Hemati et al., 2010). There are many evidences that natural products and their derivatives have efficient anti-oxidative characteristics, consequently linked to anti-cancer, hypolipidemic, anti aging and anti-inflammatory activities (Rhee et al., 2009; Wiseman et al., 1997; Hogg, 1998; Mates et al., 1999; Cho et al., 2006).

Anti-oxidative capacity of *E. arvense* stems was evaluated by the electron spin resonance (ESR) spectroscopy–spin trapping method and lipid peroxidation assay. The results confirmed that the plant suppressed the formation of lipid peroxyl radicals in both systems investigated in a dose-dependent manner. The results indicate that *n*-butanol, methanol, ethyl acetate, and aqueous extracts had significant peroxyl radical scavenging activity (Cetojevic-Simin et al., 2010).

Chronic administration of the hydroalcoholic extract of stems from *E. arvense* (HAE) reversed the cognitive impairment in aged rats related to the antioxidant properties (Dos Santos et al., 2005). Chronic administration of the extract at dose of 50 mg/kg, i.p., improved both short- and long-term retention of inhibitory avoidance task and ameliorated the cognitive performance in reference and working memory version of the Morris Water Maze. No toxicity manifestations were observed during treatment. *In vitro* assays revealed that *E. arvense* extract diminished the thiobarbituric acid reactive substances as well as nitrite formation, but did not alter catalase activity. Thus, the cognitive enhancement effects of it may be attributed, at least in part, to it antioxidant action (Dos Santos et al., 2005). The results obtained suggest that horsetail extracts could be used as an easily accessible source of natural antioxidants.

Anticancer properties

The aqueous extract from sterile stems of *E. arvense* has shown dose dependent cytotoxic effects on human leukemic U 937 cells. DNA fragmentation, externalization of phosphatidilserine, the collapse of mitochondrial transmembrane potential, was all observed in cells cultured for 48 h with the herb extract. Cytotoxicity of *E. arvense* aqueous extract against U 937 cells is due to apoptosis. It has also been reported that crude proteins extracted from *E. arvense* inhibit the proliferation of cultured cancer cells (Yamamoto et al., 2004).

Antiproliferative activity was also measured using the sulforhodamine B colorimetric assay on the human cancer cell lines HeLa, HT-29, and MCF7. Ethyl acetate extract exhibited the most prominent antiproliferative effect, without inducing any cell growth stimulation on human tumor cell lines (Cetojevic-Simin et al., 2010).

Conclusion

The objective of this article has been to illustrate *E. arvense* potential as a therapeutic agent. With the current information, it is evident that *E. arvense* has pharmacological functions including anti-inflammatory, analgesic, anticonvulsant, antihyperglycemic, antioxidant, anticancer, sedative, antibacterial and antifungal among others. It must be kept in mind that clinicians should remain cautious until more definitive studies demonstrate the safety, quality and efficacy of *E. arvense.* For these reasons, extensive pharmacological and chemical experiments, together with human metabolism will be a focus for future studies. Last but not the least, this article emphasizes the potential of *E. arvense* to be employed in new therapeutic drugs and provide the basis for future research on the application of transitional medicinal plants.

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