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Review

Phytochemical and Pharmacological Profile of an Overexploited Shrub of Rajasthan - *Calligonum polygonoides* L.

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ABSTRACT

Calligonum polygonoides L. is locally known as Phog, Phoglo etc. in western Rajasthan. It is widely distributed in arid regions of world from Saudi Arabia to desert of Rajasthan. It is an important shrub for stabilization of sand dunes. Traditionally, it is used as fuel and also for treatment of heat-stroke. Several phyto-chemicals are present in the plant for example, butanolides- calligonolides A and B, various flavanoids like quercetin and their derivatives, kaempferol, steroidal compounds, tannins etc. A number of pharmacological activities such as cytotoxic, antioxidant, antibacterial, antifungal, antiviral, and antidiabetic have been reported from the plant in scientific studies carried out world over. However, its overexploitation is causing a serious threat on its existence and raising concern for its conservation and preservation. The present paper mainly focuses on brief description of phytochemistry and pharmacology of C. polygonoides.

KEYWORDS: Antiviral, α-amylase inhibition activity, Calligonolides, Cytotoxic, *Phog.*

INTRODUCTION

In India, three species of the genus *Calligonum,* namely, *C. polygonoides* L., *C. comosum* L'Her, and *C. crinitum* Boiss. are found[1]. *Calligonum polygonoides* L. (Fig. 1 and 2) is a small perennial shrub belonging to family Polygonaceae. It is widely distributed from the arctic to the tropics with main density in Northern temperate region besides North Africa, Southern Europe, Central and Western Asia[2]. It is a native plant of Gulf States, Iran, Iraq, Kuwait, Lebanon-Syria, Pakistan, Palestine, Saudi Arabia, Sinai, Turkey, and Yemen[3]. In India, it is found mainly in the dry and arid parts of Punjab, Rajasthan, Haryana and Gujarat. In Rajasthan, it is frequently visible in Barmer, Jaisalmer, Bikaner, Jodhpur and Sriganganagar districts and commonly known as *'Phog'* or *'Phogla'*[4].

C. polygonoides is a slow growing, branching shrub (Fig. 2) with a height of one to two meters and rarely growing up to seven meter. As an adaptation to desert climate, its stem is modified into phylloclades, with very few or reduced, linear-subulate shaped leaves. Flowers are light pink in color with sweet smell and grow in axillary fascicles. Fruits are oblong nuts which are densely clothed with reddish brown bristles. Interestingly, its floral buds are consumed with buttermilk and salt and also used as vegetable. In western Rajasthan, *'Raita'* is prepared from its flowers mixed with curd and especially taken in summer season to prevent from heat stroke[5,6].

Figure 1: Habit of *C. polygonoides*

Figure 2: *C. polygonoides* Shrub

C. polygonoides is used by ethnic communities of India for the treatment of colic pain, dysuria, sore gum, typhoid, eyewash against *Calotropis procera* latex in human beings and also used for treatment of colic pain, constipation, urine problem etc. in animals[7]. A decoction of its bruised roots along with catechu is used as gargle for sore gums. The paste of this plant and shoot juice act as antidote against the heavy intake of opium[8]. Flower buds of this plant have cooling properties and used to prevent sunstroke. Its stem juice is also employed as an antidote to scorpion bite[9].

Whole plant of *C. polygonoides* is used as fuel and stem and branches are used for making roofs and huts in western Rajasthan. The coal, prepared from this plant is used by blacksmiths. The plant is also a common feed of desert locust *(Schistocerca gregaria* Forsk). It is also used as a green fodder in deserts and eagerly browsed by camels and during flowering; it is readily eaten by animals as a good source of nutrients[5]. Ecologically, *C. polygonoides* is very important due to its capacity to prevent erosion, stabilize the shifting sand dunes, and increase the organic matter content in the soil[10]. It can grow well in both high and low temperature stress under arid conditions and grows commonly on dry sandy soils. As an abiotic stress-tolerant shrub of sand-dunes eco-system, it is well-known for its leaf-fodder, energy-rich fuel-wood, and flower-buds. It is considered as a dominant biomass producer under extremes of concurrent abiotic stresses at sandy areas of the Thar Desert[11]. However, it is fast disappearing from its natural habitats as a result of excessive cutting for fuel wood and digging for many other purposes and therefore, its distribution is now being restricted to few dispersed areas in western Rajasthan.

Nutritionally, *C. polygonoides* is rich in several macro- and micro-nutrients. Vyas *et al.*[12] assessed several chemical and mineral components from *C. polygonoides* and found that the plant is a very good source of calcium, potassium, and phosphorous and a fair source of zinc whereas crude fibre, crude protein, and total carbohydrate content of *C. polygonoides* was found to be equivalent to legumes[13,14]. Rathore[15] reported the nutritional content of flower buds of *C. polygonoides* as ash (11.14%), dietary fibres (44.98%), fat (1.27%), sugar (9.75%), protein (8.02%), vitamin C (66.88 mg/100g) as well as presence of several minerals such as Cu, Zn, Fe, Mn, Mg, Ca, P, K and Na.

C. polygonoides possess high economic value as all its plant parts are utilized for different purposes. It is a rich source of phenolic compounds and shown to possess 13–35% phenolic compounds on dry weight basis with major portions of gallic acid, catechin, vanillic acid, chlorogenic acid, epicatechin, coumaric acid, catechol, and syringic acid[16]. A number of pharmacological activities like antioxidant, antibacterial, cytotoxic, antiviral, antifungal etc. has been demonstrated from various parts of the plant in scientific studies[8,17,18]. In the present paper, phytochemical and pharmacological profile of *C. polygonoides* has been discussed in detail.

METHODOLOGY

For this purpose, online databases such as Google Scholar, Pubmed, Springer Link, Science Direct, Scopus and Research gate were thoroughly searched using the keyword *Callignoum polygonoides* in combination with others such as Pharmacology, Phytochemistry, Ethnomedicine, Chemical Constituents, and Herbal medicine. Information thus obtained regarding Phytochemistry and Pharmacological activities of *C. polygonoides* is presented below under separate headings.

Phytochemical Profile

Samejo *et al.*[19] reported the presence of different secondary metabolites *viz.*, phenolics, tannin, flavonoids, steroids and terpenoids in different parts of the plant. Various plants produce secondary metabolites such as phenolic compounds to safeguard themselves from abiotic stressors. These phenolic

bioactives could be isolated and utilized for the formulation of functional foods with high antioxidant activity. Some of the major phyto-constituents isolated from the various parts of the plant are depicted in Table 1. Flavonoids were mainly observed in the buds, seeds, flowers, and stem of *C. polygonoides.* Alkaloids were observed in the roots, buds, and seeds but not in the stems or flowers. Proteins were found in the flowers and seeds but not in the roots, stems and buds. Roots, stems, buds, flowers, and seeds all contained tannins, phenols, steroids, carbohydrates, and terpenoids. The flowers and seeds of *C. polygonoides* are also the main source of proteins[8].

Acyclic diterpene alcohol, oxygenated monoterpenes, sesquiterpenes, sesquiterpene alcohols, triterpenes, tricosane, nanocosane, heptacosane, pentacosane, tetracosane, 1,2-benzenedicarboxylic, and mono (2-ethylhexyl) adipate are some of the compounds found in the buds and roots of *C. polygonoides*[25]. Samejo *et al*.[21] have shown that essential oil isolated from floral buds of *C. polygonoides* is a good source of phenolics compounds (12.98%), acid derivatives (12.99%), and essential oil obtained from the roots is rich in hydrocarbons (29.65%) and sesquiterpene alcohols (29.42%). Calligonolides A and B, two novel butanolides, a new steroidal ester, tetracosan-4-olide, *β*-sitosterol and its glucoside, and ursolic acid were reported from the whole plant of *C. polygonoides* plant[26].

Interestingly, several flavonoids such as kaempferol-3-O-β-D-(6″-n-butyl glucuronide), quercetin 3-O-β-D-(6″-n-butyl glucuronide), kaempferol-3-O-β-D-(6″-methyl glucuronide), quercetin-3-O-α-rhamnopyranoside, quercetin-3-O-β-D-(6″-methyl glucuronide), quercetin-3-O-glucuronide, kaempferol-3-O-glucuronide, astragalin, quercetin-3-O-glucopyranoside, taxifolin, (+)-catechin, dehydrodicatechin A, quercetin and kaempferol have also been isolated from aerial parts of *Calligonum polygonoides* L. subsp. *comosum* L' Hér and among which Quercetin has shown significant cytotoxic activity against liver HepG2 and breast MCF-7 cell lines with IC_{50} values of 4.88 and 0.87 µg/mL, respectively using sulphorhodamine-B assay[27]. Some anti-inflammatory flavanoids have also been isolated from its aerial parts such as kaempferol-3-O-β-D-glucuronide, taxifolin, mequilianin, catechin, which have shown NF-κB inhibition on HEK293 cells[28].

Pervaiz[29] has isolated ten bioactive compounds, three sterols from n-hexane fraction and seven flavonoids/ glycosides from n-butanol fractions of *C. polygonoides* using modern spectroscopic techniques such as Infra Red, Nuclear Magnetic Resonance and mass spectrometry. Recently, Ahmed *et al.*[30] demonstrated 6.055 mg GAE/g total phenolic content and 5.706 mg RU/g total flavonoid content in the plant extract of *C. polygonoides.*

Table 1: Major Phytochemicals Isolated from Various Parts of *C. polygonoides* L.

Plant Part	Chemical Compounds	References
Root	Stigmasterol, (3b,5a,24S)-stigmastan-3-ol, stigmast-4-en-3-one, campesterol, Diterpene alcohol, oxygenated monoterpenes, sesquiterpenes, sesquiterpene alcohols, triterpenes, tricosane, heptacosane, pentacosane, tetracosane, 1,2-benzenedicarboxylic, and mono (2-ethylhexyl), Docosane, Drimenol, 2-Nonadecanone, Mono (2-ethylhexyl) ester-1,2- benzenedicarboxylic acid, Squalene, Nonacosane	Dhief *et al.*[20]; Samejo *et al.*[21]
	Pyrogallol, palmitic acid, 1-Ethyloctyl methyl sulphide, acetic acid, and 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl, 3-methylpentane, 3-Methoxy-5-methyl-4-nitrophthalic acid, acetasol, catechol, 5-Bromouridine, β-hydroxyethyl isopropyl ether, 1,6-Dideoxy-2,4-O-methylenehexitol, citronellyl acetone	Abd-ElGawad *et al.*[22]
Leaves	Kaempferol, quercetin, isoquercitrin, quercetin-3-o-glucuronide, taxifolin, quercitrin, catechin, gallic acid, astragalin, kaempferol-3-o-glucuronide	Ahmed *et al.*[23]

Continued ...

Plant Part	Chemical Compounds	References
Bud	Diterpene alcohol oxygenated monoterpenes, sesquiterpenes, sesquiterpene alcohols, triterpenes, tricosane, nanocosane, heptacosane, pentacosane, tetracosane, 1,2-benzenedicarboxylic, and mono (2-ethylhexyl),2-Methoxy-4-vinylphenol, Benzenepropanenitrile, Ethyl homovanillate, 4-(2,6,6-Trimethylcyclohexa-1,3-dienyl)but-3-en-2-on, E-β-Ionone, Methyl jasmonate, Phytol, Neophytadiene, (Z, Z, Z)-9,12,15-Octadecatrienoic acid,13-Tetradece-11-yn-1-ol, Docosanoic acid methyl ester, Mono (2-ethylhexyl) ester-1,2- benzenedicarboxylic acid, Heneicosane, 1,19-Eicosadiene, Heneicosanoic acid methyl ester	Dhief *et al.*[20]; Samejo *et al.*[21]
	Catechin, delphinidin, callistephin, fisetin, myricetin, kuromanin, rutin, epicatechin, and procyanidin A2	Gomes *et al.*[17]
Stem	Kaempferol, quercetin-3-o-glucuronide, kaempferol-3-o-glucuronide, quercetin, taxifolin, quercitrin, catechin, gallic acid, astragalin, isoquercitrin	Ahmed *et al.*[23]
Bark	Kaempferol, quercetin, taxifolin, quercitrin, isoquercitrin, catechin, gallic acid, astragalin, kaempferol-3-o-glucuronide, quercetin-3-o-glucuronide	Ahmed *et al.*[23]
Fruit Oil	(Z, Z)-9,12-octadecadienoic acid, hexadecenoic acid, nanacosane, hentriacontane, tetradecanoic acid, heptocosane, dodecanoic acid and pentacosane	Samejo *et al.*[24]
Flower	Kaempferol, quercetin, taxifolin, quercitrin, catechin, gallic acid, astragalin, isoquercitrin, kaempferol-3-o-glucuronide, quercetin-3-o-glucuronide	Ahmed *et al.*[23]
Stem Oil	Hexadecenoic acid, (Z, Z)-9,12 octadecadienoic acid, nonanoic acid, dodecanoic acid, tetradecanoic acid, (R)-massoia lactone, and pentadecanoic acid	Samejo *et al.*[24]

Pharmacological Profile

Some therapeutic activities (Fig. 3) have also been demonstrated from various parts of *C. polygonoides* such as anti-bacterial, anti-fungal, anti-viral, anti-oxidant, cytotoxic and anti-diabetic[8,17,18]. Additionally, it has also shown the ability to block the lipoxygenase enzyme[26]. Recently, Nisa *et al.*[31] evaluated the pharmacological effects of a 70% hydro-alcoholic extract of *C. polygonoides* in animal models on the gastrointestinal, respiratory, and circulatory systems. It was discovered that K+ induced (80 mM) and spontaneous contractions were both significantly reduced when the plant extract was present. This revealed the vasodilator, bronchodilator, and spasmolytic potential of *C. polygonoides.*

Antimicrobial activity

Sadiq[32] assessed the biochemical, phytochemical, and biological potential of various parts of *C. polygonoides.* Its stem, root, and flower were used to prepare several extracts, using water, methanol, ethyl acetate, ethanol, and n-hexane.

Methanolic extract of *C. polygonoides* L. subsp. *comosum* exhibited strong antibacterial potential against different gram positive (*Staphylococcus aureus* and *Bacillus subtilis*) with a minimum inhibitory concentration (MIC) of 0.12 and 0.03 µg/ml, respectively and gram-negative bacterial strains (*Pseudomonas aeruginosa* and *Klebsiella pneumoniae*) with a MIC of 3.9 and 0.03 µg/ml, respectively. Methanolic extract also inhibited growth of fungi, namely, *Aspergillus fumigatus* and *Candida albicans* with MIC of 0.24 and 1.95 µg/ml, respectively[33].

Antifungal potential of methanolic extract of whole plant of *C. polygonoides* has also been demonstrated at 1000µg/mL and growth inhibition of *Aspergillus niger, Aspergillus flavius, Aspergillus fumigatus* was found to be 70, 50.7 and 50 % respectively[34]. The antifungal activity of roots of *C. polygonoides* with its methanolic, aqueous, hexane, and ethyl acetate extracts has also been demonstrated by Ahmad and Akram[35]. Notable inhibitory effects of *C. polygonoides* were observed against *Candida albicans* without any effect on *Aspergillus niger.* The minimum inhibitory concentration (MIC) for *C. polygonoides* methanolic root extract was found to be 6.5 µg/ ml, with a concentration-dependent increase in the inhibition against *C. albicans* whereas its ethyl acetate extract exhibited MIC of 9.8 µg/ ml against the fungus *C. albicans.*

Methanol, ethyl acetate, ethanol and n-hexane extracts of stems, roots and flowers of *C. polygonoides* were also tested against Avian Influenza Virus (AIV) H9N2 and Infectious Bronchitis Virus (IBV). All the extracts, in the case of AIV H9N2 had shown good antiviral potential. Methanolic and ethanolic extracts of stems and roots have demonstrated the strongest antiviral activity in case of IBV. Extracts of flowers were more effective than stems and roots in suppressing IBV[32].

Antioxidant activity

Kumar *et al.*[9] reported radical scavenging activity of various parts of *C. polygonoides.* It was revealed that methanolic extract of stems possess maximum scavenging potential, whereas in case of roots and flowers, ethanolic extract showed higher potential. The dose dependent antioxidant potential was exhibited by extracts of stem, root and flower. The n-hexane and aqueous extracts of stems and flowers were not active at lower concentrations like 1.56 mg/ml and 3.125 mg/ml but as the concentration was increased to 50mg/ml and 100mg/ml significant antioxidant potential was observed. In case of flowers, low activity was depicted by most of the extracts at lower concentrations but at high concentration, all the extracts exhibited strong antioxidant potential

Free radical scavenging property of the whole plant of *C. polygonoides* was assessed in different *in vitro* assays and dose-dependent scavenging results were obtained such as, 78.1% against 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals, 83.1% to 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radicals and 56% against superoxide radicals at a concentration of 500 µg/ml[34]. Samejo *et al.*[36] have shown the phenolic content and identification of phenolic compounds in the methanol extracts of *C. polygonoides* stem and buds having antioxidant potential. By using high-performance liquid chromatography, 11 and nine phenolic compounds from the stem and buds respectively, were discovered and measured. Buds were found to be rich in gallic acid and p-coumaric acid predominated in the stem. The strongest antioxidant activity was observed in the samples with the highest phenolic levels.

C. polygonoides aerial component was extracted with methanol and divided into three portions based on polarity (n-hexane, chloroform and n-butanol). The inhibitory activities against xanthine oxidase, carbonic anhydrase, β-glucosidase, tyrosinase, and urease were assessed in the crude extract and polarity base fractions. Both the crude methanolic extract and the n-butanol extract significantly inhibited the enzymes, xanthine oxidase (IC_{50} values 43.68±0.4 and 37.74±0.56 µg/ml), carbonic anhydrase (IC_{50} values of 46.94 ± 0.4 and 32.31± 0.6 µg/ml) and α-glucosidase with (IC50 values 59 ± 0.64 and 27.61±0.18 µg/ml). All other fractions failed to inhibit tyrosinase enzyme. Notably, n-hexane fraction displayed strong activity against urease enzyme (IC_{50} value of 12 ± 0.68 µg/ml). The two most bioactive fractions from n-hexane and n-butanol were proceeded for isolation of bioactive compounds and total ten compounds were identified out of which sterols displayed remarkable urease inhibitory activity and isolated flavonoids from the n-butanol fraction strongly inhibited carbonic anhydrase, xanthine oxidase, and α-glucosidase[29].

The presence of several phytochemicals, including dehydromevalonic lactone, deoxyspergualin, 2-methoxy-4-vinylphenol, furan-2,5-dimethyl, 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-Pyran-4-one (DDMP), linolenic acid, benzene ethanol-4-hydroxy, quinic acid, lauric acid, and squalene in flower buds was observed which also possess various bioactivities for example, anti-mutagenic, anti-cancer, anti-oxidant, anti-inflammatory, hepatoprotective etc.[16].

Berwal *et al.*[37] also studied the effect of seasonal variation on total phenolic content, tannin content and antioxidant activity of leaves of *C. polygonoides.* A substantial positive connection between phenolic components and antioxidant activities was observed indicating that phenolic compounds are important antioxidant chemicals present in the leaves of *C. polygonoides.* Results of Cupric reducing antioxidant capacity revealed maximum activity during June (118.84 ± 2.12 mg ascorbic acid equivalent/g) and lowest in October (51.22 ± 1.14 mg ascorbic acid equivalent/g). Similarly, Ferric reducing antioxidant power assay revealed highest capacity during December (27.11 ± 0.20 mg ascorbic acid equivalent/g) and lowest in the month of October (18.26 ± 0.21 mg ascorbic acid equivalent/g) and DPPH assay also exhibited maximum antioxidant capacity of its leaves in December (105.46 ± 2.72 mg ascorbic acid equivalent/g) and lowest in October (43.42 ± 3.14 mg ascorbic acid equivalent/g). The highest total tannin content was observed in December (96.09 ± 1.38 mg catechin equivalent/g) and the lowest in March (40.4 ± 0.89 mg catechin

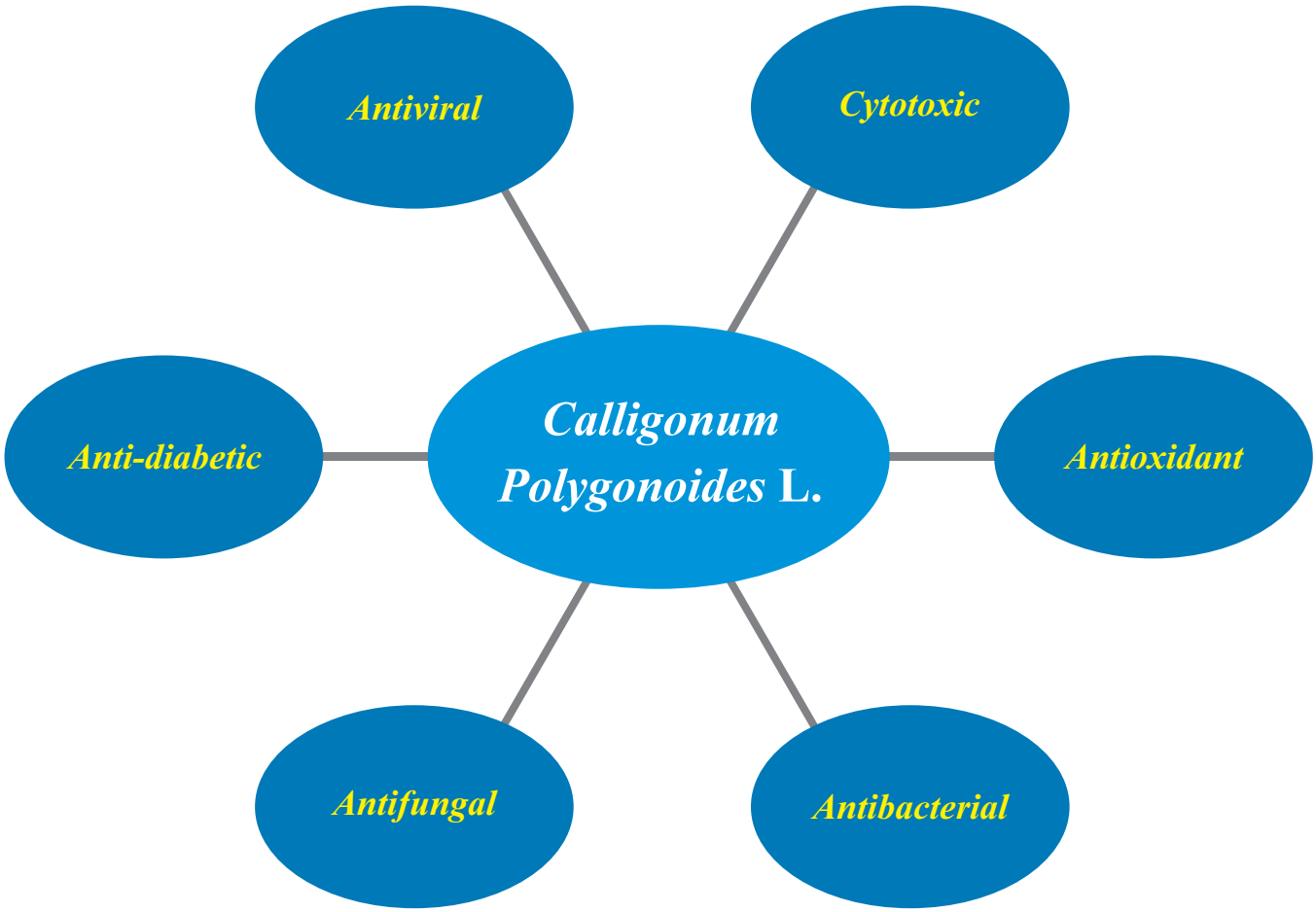

Figure 3: Pharmacological Profile of *Calligonum polygonoides* L.

equivalent/g). Similarly, the highest total flavanoid content was observed in December (2.80 ± 0.02 mg catechin equivalent/g) and the lowest in the month of March (1.0 ± 0.0 mg catechin equivalent/g) and the highest total phenolic content was reported in December (88.08 ± 0.59 mg gallic acid equivalent/g) and the lowest in March (32.28 ± 0.54 mg gallic acid equivalent/g). Overall, it suggests that June and December are the best months for getting optimal antioxidant results from *C. polygonoides*. This further reflects the importance of time of harvesting on the concentration of bioactive molecules and efficacy of biological activities.

Anti-diabetic activity

In vitro anti-diabetic activity of *C. polygonoides* was observed by inhibition of α-amylase and β-glucosidase enzymes[30]. A 70% α-amylase inhibition activity of *C. polygonoides* extract with IC_{50} of 610 µg/ml and 65% β-glucosidase inhibition activity with an IC_{50} value of 640 µg/ml was observed. In case of stem, aqueous and ethanolic extracts were highly active and showed 95.52% and 94.72% inhibition respectively. The aqueous and ethyl acetate extracts of roots showed 90.4% and 63.84% inhibition respectively. Methanolic extract of flowers has shown 92.08% inhibition of α-glucosidase.

Cytotoxic activity

Khan *et al.*[34] have shown that methanolic extract of *C. polygonoides* whole plant had dose-dependent cytotoxic effect against brine shrimps. At 1000µg/ml concentration of plant extract, a brine shrimp death rate of 80% was seen. This reflects the cytotoxic potential of plants and therefore, it could be further screened against cancer cells.

Miscellaneous

Sher *et al.*[38] examined the biological production and pharmacological properties of silver nanoparticles (AgNPs) prepared by employing the methanolic crude extract of the *C. polygonoides*. AgNPs were produced from 10 mM AgNO3, as demonstrated by UV visible and FT-IR spectroscopy. The AgNPs were spherical, monodispersed, and had an average size of 50 nm and demonstrated potential for *in vitro* anti-diabetic, anti-fungal, antioxidant, cytotoxic, and antibacterial effects.

The industrial effluent containing both inorganic and organic toxic material is discharged into surface water that seriously affects biodiversity, ecosystem functioning and natural activities of aquatic system. One of these contaminants is synthetic dye, which is regarded as the most prevalent and harmful water pollutant[39,40]. The removal of textile dyes from aqueous environments can be accomplished using a variety of physical and chemical techniques. These include electrokinetic and adsorption techniques, ion exchange, membrane filtration, electrochemical oxidation, ozonation, flotation, chemical coagulation, and biological and chemical oxidation[41-43]. In this regard, development of a potential benign biosorbent from ash of *C. polygonoides* for removal of methylene blue dye from aqueous solution is an important discovery for protection of environment[44]. Rathore *et al.*[45] have shown that *C. polygonoides* helps in restoration of degraded land and amelioration of soil by enhancing water holding capacity of soil as well as increasing the levels of organic carbon, nitrogen, phosphorus and electrical conductivity. Therefore, this shrub could be planted in the arid regions to restore the degraded soil.

Rizwanullah *et al.*[46] evaluated the dyeing potential, pharmacological relevance, and phytotoxicity of a unique natural dye isolated from the root bark of *C. polygonoides.* Phytochemical analysis of the dye solution revealed that it contained a lot of natural phenolics. Antibacterial action of the dye was assessed against various bacterial strains, like, *Klebsiella pneumoniae, Staphylococcus aureus, Acinetobacter baumannii,* and *Escherichia coli.* The zone of inhibition against *E. coli* (13 mm), *A. baumannii* (17 mm), *K. pneummoniae* (20 mm), and *S. aureus* (15 mm) was observed at a dose of three mg/ml. When the dye's antifungal effectiveness was evaluated, it demonstrated a 17% reduction in fungal growth when used at a concentration of 3 mg/ml against *A. niger*. The germination of maize in various concentrations was used to test the phytotoxic effect of *C. polygonoides* dye (250-1000 ppm). There was no evidence of a phytotoxic effect of the dye on the growth and development of maize seedlings. They also tested the dye to determine whether it could dye cotton fibres. When acetic acid was employed as a mordant with the dye, it was noticed that the cotton fabric was stained with a bright red colour and the dye was resistant to repeated washings with tap water. This suggests that the dye obtained from *C. polygonoides* root bark, is safe, effective at dying cotton fibres, and has antibacterial and antioxidant effects.

Conservation Issue

This shrub is extensively used in western Rajasthan for fuel purpose and therefore, cut in huge quantities. Besides, habitat loss for cultivation purpose or for development of industries has also jeopardized its existence in the arid region of the Rajasthan. The issue of its fast depletion and impact on desert ecosystem has been raised. In fact, over-exploitation has led to up-rooting of many of its natural population[47,48]. However, the conservation efforts have not been initiated at large scale. Hence, it is a clarion call for environmentalists to protect this multiple utility plant from untimely demise.

CONCLUSION

C. polygonoides is a small shrub growing in the arid regions of India such as in the desert of Rajasthan. It can very well tolerate high and low temperature and dry sandy soil conditions. *C. polygonoides* has also been mentioned for treatment of various ailments in ethnomedicine such as, colic pain, dysuria, sore gum, typhoid etc. Nutritionally, the plant is rich in protein, carbohydrates, vitamins and minerals. Interestingly, therapeutic role of *C. polygonoides* has been scientifically proven through its pharmacological activities like antioxidant, antibacterial, antiviral, cytotoxic, antifungal etc. Various phenolic compounds, flavanoids, steroids, alkaloids impart the plant a strong armour against pathogens. In fact, these phytochemicals could also be beneficial for human beings by protecting against several diseases. These health-beneficial pharmacological activities play a significant role in modifying abnormal oxidation, abnormal cell growth and high sugar levels. However, its overexploitation for fuel purpose is jeopardizing its population and therefore, urgent actions are required to conserve this species for future generations.

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CONFLICTS OF INTEREST: None

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