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A phyto-pharmacological overview on *Salvadora oleoides* Decne

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Salvadora oleoides Decne belonging to the family Salvadoraceae is a small, multipurpose tree commonly grown in western Rajasthan and Gujarat states of India. It is also known as *Jhal* and *Badapilu*. Many chemical constituents such as carbohydrates, alkaloids, steroids, glycosides, saponins, tannins, triterpenes, mucilage, fats and oils have been reported from its leaves and stems extracts. Because of the presence of these active chemical constituents it possesses anti-inflammatory, analgesic, anti-ulcer, anthelmintic, antibacterial, antifungal and diuretic activities. This review summarizes the traditional claims, phytochemistry and pharmacology of *S. oleoides* reported so far in scientific literature.

Keywords: *Salvadora oleoides*, *Jhal*, *Badapilu*, Phytochemistry, Pharmacology, Pharmacognosy.

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Introduction

Salvadora L. genus belongs to the family Salvadoraceae, a family of 3 genera and 12 species, distributed mainly in tropical and subtropical Asia and Africa. In Pakistan, family is represented by one genus with two species, viz. *S. persica* L. and *S. oleoides* Decne. Both species are deep rooted mesomorphic xerophytes as well as facultative halophytes with high salt tolerance[1-10] which can be differentiated on the basis of morphological and biochemical parameters of leaves, fruits, seed and pollen grains[11-14]. *S. oleoides* is a small, multipurpose tree commonly grown in western Rajasthan and Gujarat states of India[15]. It is commonly known as *jhal, badapilu, pilu, vridhpilu* and *khakan* [3, 15-20]. The tree is primarily sourced for its fruits known as desert grapes. This species is decreasing very rapidly due to over exploitation, indiscriminate collection, low rate of seed set, poor viability and inefficiency of propagation by vegetative means[21-23].

S. oleoides is commonly found in tropical Africa and Asia, extending to Egypt, the Mascarene Islands and China. This species grows on dry, saline and desert areas of Rajasthan, Haryana, Punjab, Gujarat, and Madhya Pradesh. It grows well in the sand dunes of deserts to heavy soils, non-saline to highly saline soils and dry regions to marshy semi-arid (closer to arid) and waterlogged areas[24-28]. It is distributed to some extent in Andhra Pradesh, Karnataka and Tamil Nadu. It is also found in the Sunderban mangroves of West Bengal and in the regions of Chilka lagoons. The tree species is known to tolerate a very dry environment with mean rainfall of less than 200 mm in Barmer, Jalore, Jodhpur and Pali districts of Rajasthan[24,28]. This species is also suitable for shelterbelts and windbreaks in arid zones and used to reduce soil erosion. It survives at an altitude of 1000 m[15, 16, 29].

Propagation

Poor seed germination, low seed viability and increasing industrialization are some of the constant factors which significantly affect the status of the natural population of this plant. The risk status of *badapilu* is perceived to be under threat (regional vulnerable) and has been recommended for conservation on high priorities[23]. It can be regenerated by seeds, coppices, root suckers and through tissue culture technique[30]. The species, however, is very slow growing. Natural regeneration from seeds is rare, probably because seeds mature at the onset of the monsoon season, so more susceptible to fungal attack[28, 31].

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A research was done on their seed germination by soaking them in cold water for 2 h or in hot water for 0.5 h; control untreated seeds took 30 h to germinate. Germination after 50 h was 80-100% in these treatments. 100% germination occurred in seeds treated by mechanical scarification (partial seed coat removal), with medium sized seeds performing best. Otherwise, there was little difference between large, medium and small sized seeds[31]. Calcium can affect the seedling growth of *S. oleoides* (*methajal*) grown under saline conditions[32]. The seeds of *S. oleoides* are not stored because viability is not retained. It is therefore, recommended that fruits are immediately depulped[33]. Depulping the fruits and pre-treating the seeds promote early germination. Freshly harvested seeds with 26 % moisture content showed 90 % germination. Viability of seeds is reduced by 50 % 15 days after harvest and 100 % after 24 days of storage. Excised embryonic axes from the stored seeds showed better viability as compared to whole seeds. This indicates the presence of some inhibitory substances in the cotyledons which cause the lower viability of seeds[34].

Macroscopy

Morphological examination of the plant *S. oleoides* reveals that it is a shrub or tree; attaining 6-9 m height under favourable conditions, trunk short, often twisted or bent, up to 2 m in diam., branches stiff, rough, spreading, often swollen at forks, yellow green, surface glaucous with trichome[3,16,17]. The presence of trichomes on branch surface is a distinguishing character of this species[35,36]. Its bark is grey or whitish grey[3,16,17]. Leaves are glaucous, linear, ovate or lanceolate, coriaceous and somewhat fleshy, dark greenish yellow when young, grey when mature and leaf size ranges from 3-10 cm x 0.3-1.2 cm. New leaves usually appear in April [3,16,17,28]. Its petiole is 2-l.2 cm long; lamina 1.5-7.5 cm long, 4-1.5 cm broad, elliptic-lanceolate, mostly acute, rarely obtuse or mucronate glabrous with obscure lateral veins[35]. The leaves are fleshy and have a pungent odour[28]. The flowers are sessile, greenish white in colour and clustered.

The tree generally flowers in March-April. Inflorescence axillary panicles or branched spikes, 2.5-4 cm long often clustered. Flowers greenish white, 2-3 mm across; pedicel 1 mm long or absent. Calyx 1.5-2 mm long, with round lobes and wavy margin, divided nearly half way down, glabrous. corolla 2.5 mm long, obovate or oblong; lobes sub-acute and recurved. Stamens 4, inserted at the base of the corolla tube. Style absent and stigma is peltate. Fruit a drupe, clustered, 5 mm in diam., globose, reddish brown fruits or red when dry. They are sweet with a bit of pungent taste. In some cases, the fruits are pink and violet. The fruits can be harvested in June [1-4,16-17,28,35]. Seeds are greenish-yellow, about 3 mm in diam., globular, 6.54 μm long and 5.24 μm wide. Seed surface show reticulate pattern with small pits. The cells are regularly or irregularly arranged in circular rows[35,36]. Pollen morphology of Salvadoraceae family has been studied by researchers. On the basis of pollen grains two species of *Salvadora* can be easily differentiated. In *badapilu* pollen grains are generally radially symmetrical, isopolar, 3-zonocolporate rarely 4-zonocolporate, prolate- spheroidal to sub-prolate[37-41].

Microscopy

Leaves

Both surfaces of leaves have sunken stomata and almost of the same size and uniformly distributed on both surfaces. This species has very distinct pattern on both the surface of leaf as compared to other species of *Salvadora*. Epidermal cells are of two different shapes, few are circular and bulging and others are forming rows of elongated suppressed cells. Both surfaces of leaf show trichomes which are very sparsely distributed on the surface but found more near to the margin. Trichomes are simple non-glandular and unicellular (ca 35.1-36.2 μm). The presence of trichome on leaf surface is a distinguishing character of this species[35-36].

Stem

Transverse section of stem bark shows epidermis. Epidermis consists of single layer of cells which are closely packed. The walls are thickened and covered with a thin water proof layer called the cuticle. Stomata with guard cells are found in the epidermis. Collenchyma with three to four layers of cells with cell walls thickened present at the corners. Beneath the collenchyma cells are a few layers of thin-walled cells, parenchyma, with intercellular spaces. The phloem is located towards the outside of the bundle and the xylem towards the centre. The pith occupies large central part of the stem[42].

Phytochemistry

Various qualitative chemical tests revealed the presence of carbohydrates, alkaloids, steroids,

glycosides, saponins, tannins, triterpenes, mucilage, fats and oils in the leaf and stem extracts[35,42-43].

Likewise, seeds contain 40-45% oil which is a mixture of fatty acids. This oil holds good economic significance[19,44]. Fruits contain glucose, fructose, sucrose and are good source of calcium[19,45]. Dibenzylurea thiourea has also been reported from this species[46]. The seeds have flavonoids like quercetin, rutin and its seed fat contains lauric, capric, malic acid, myristic, palmitic, oleic, linolenic acid, dibenzyl urea and proteins. All these constituents of oil can be used as mosquito repellants[20-21,47-50]. Salvadorin, a new dimeric dihydroisocoumarin has been isolated from the chloroform fraction of *S. oleoides*. Its chemical structure was established as 8-benzyl-6-[6-(6-ethyl-7-methyl-5, 8-dihydro-2-naphthalenyl)-1-oxo-3, 4-dihydro-1*H*-isochromen-8yl]-3,4-dihyro-1*H*-isochromen-1-one, through spectroscopic techniques and chemical analysis[51]. A new compound, heptadecanoyl-2-methyl-heptanoate has been isolated from stem bark. The ester has been characterized on the basis of chemical reactions and spectroscopy studies[52]. Methanolic extract of *S. oleoides* showed the presence of two novel polyamides with a molecular formula of $C_{35}H_{65}N_5O_{15}$ and $C_{35}H_{65}N_5O_{10}$ [(Ref.53)].

Traditional uses

This tree species is having a number of proven medicinal applications and almost all parts have been found to be pharmaceutically important. Decoction of leaves is given to the cattles to promote the expulsion of dead fetus from the uterus. The leaves were used as a cooling agent, blood purifier, laxative, expectorant and also used as purgative in horses[19,54]. Leaves are also used to employ in the treatment of enlarged spleen and low fever. The leaf paste was applied on an open wound to treat inflammation of legs and its extract was recommended for relief of abdominal pain in new born babies. Leaf juice can also be used for anemic patients[55]. They also possess anti-inflammatory, analgesic and anti-ulcer activities[54-57]. The leaves are also good sand binders and are considered as good fodder for goats and camels. Goats, sheep and camels consume foliage round the year but the young tender leaves, which appear in spring season, are more eagerly devoured by the grazing animals. Ash of leaves is boiled in water and used for removing hair from camels. Stem possesses an anthelmintic and diuretic activity[56-57]. Root bark is used as vesicant[54]and also used in the treatment of piles[56-57] and chest disease while its latex is used for treating sores[58-59]. Fruits are sweet with cooling effect and employed in the treatment of enlarged spleen, rheumatism, low fever, piles, tumor, bronchitis, child birth and snake bites[49, 54, 60-61]. The fruits are eaten by local people but are believed to produce tingling and small ulcer in the mouth if taken in excess. The fruit is still popularly regarded as an aphrodisiac and the extract of dried fruits is used as a medicine for treatment against cold[62]. Fruits are fed to cattles to increase the milk yield[63] and are consumed during draught period to mitigate the deficiency of salts and other essential electrolytes in the human body. The fruit of the tree is also relished by a variety of insects, birds and rodents[64]. Seeds contain 40-50% of a greenish yellow non-edible fat. Seed oil being non edible is reported to be a potential industrial substitute of coconut oil in candles and soap making. Seed oil is widely used in commercial production of cosmetics, paints, varnish, lubricants[20] and as an ointment base for the treatments of rheumatism[54,64-67]. Seeds are used in the treatment of cough[56,57]. The seed cake is also used as livestock fodder[47]. The acids are used to produce lauryl alcohol[47]. Seed oil of *S.oleoides* and *Xanthium strumarium* L. when mixed in 1:1 ratio, the resulting mixture meets the specifications of biodiesel standard[68]. The whole plant is used as diuretic, cooling herb, anti-inflammatory agent, wound healing herb and nerve tonic, in the treatment of various uterine and skin disorders by the local people of Kachchh region[56,57]. The tree is often lopped for fodder to increase milk production in camels. Wood is soft and light and is widely used by rural people. Since it is considered to be resistant to ant and termites attack, used for rafters in houses, building of agricultural implements, Persian wheels and the keels of boats. The wood is used as fuel when mixed with deodorant and pine scrap wood[50].

Pharmacological uses

Anti-oxidant activity

Crude extracts of fungal endophytes from *S. oleoides* have shown positive activity. The antioxidant potencies of acetonic extracts of all fungi were significant as compared to the methanolic and aqueous extract[69].

Hypoglycemic and hypolipidemic activity

The ethanolic extract of aerial parts of *S. oleoides* produced significant reduction ($p < 0.001$) in blood glucose and also showed beneficial effects ($p < 0.001$)

on the lipid profile in euglycemic as well as alloxan-induced diabetic rats at the end of the treatment period (21 days). However, the reduction in the blood glucose and improvement in lipid profile was less than that achieved with the standard drug tolbutamide[70]. Another study has revealed that the butanol fraction of methanolic extract of leaves not only resulted in significant reduction in cholesterol, triglyceride, LDL, VLDL level but also increases the HDL level[71].

S.oleoides (*methajal)* also showed effect on blood glucose level with the combination of *Coccinia indica* Wight & Arn. The Combined Methanolic Extract (CMEt) of the two plants at a dose level of 150 mg/kg showed significant ($p<0.01$) reduction in blood glucose level of diabetic rats compared to that of standard drug Glipizide (5 mg/kg body weight). They showed significant ($p<0.01$) effect on lipid profile, ALS/AST activity and serum creatinine and urea levels, there by exhibiting its overall significant antidiabetic potential[72].

Antimicrobial activity

Research has been done on root and stem benzene extracts of *S. oleoides* which showed significant antimicrobial activity compared with standard drug streptomycin[73]. Another research showed that acetone and methanolic endophytic fungal extracts obtained from *S. oleoides* showed greater antimicrobial activity as compared to their water extract[74]. The methanolic and aqueous extracts of the stem bark exhibited moderate antibacterial activity with all the tested strains of microorganisms at 250 µg/mL conc. on comparison with the standard ciprofloxacin. Alcoholic extract of leaves showed limited activity against *E. coli* and strong activity against *S. aureus.* However, aqueous extract showed no activity against *E. coli* and limited activity against *S. aureus*[75]. Alcoholic extract of leaves are found to possess antifungal activity[76].

Anti-inflammatory activity

The anti-inflammatory effect of chloroform, ethyl acetate, alcohol and water extracts of *S. oleoides* leaves were tested on various animal models. All the extracts were tested at the dose of 200 and 400 mg/kg body weight. Out of all the extracts, chloroform and ethyl acetate extracts of leaves of *S. oleoides* does not produce significant anti-inflammatory activity, while alcohol and water extracts, at the dose of 400 mg/kg body weight have shown anti-inflammatory activity. The exhibited anti-inflammatory activity was comparable with the standard drug Indomethacin [43].

Larvicidal activity

S. oleoides seed oil was tested against larvae of *Aedes aegypti*, *Culex fatigans* and *Anopheles stephensi* at 0.01, 0.1 and 1.0% conc. Out of all the larvae, seed oil showed 100 % toxicity against *A. stephensi* at 0.01 percent[54, 77].

Cytotoxicity activity

Two polyamides isolated from methanolic extract of *S.oleoides* (*methajal)* were tested for their cytotoxicity activity against breast, liver and colon cancer cell lines. Both polyamides had shown weak activity against all cell lines. However, good activity was observed against fungus and both Gram positive and Gram negative bacteria[53].

Conclusion

S. oleoides population is decreasing day by day due to poor seed germination, low seed viability and inefficiency to propagate by vegetative means. Despite being a multipurpose plant, its chemotherapeutic value has not been fully substantiated and the mode of action of its bioactive compounds against diseases has not yet been established. Alkaloids, terpenoids, flavonoids and glycosides which were isolated from this plant may be responsible for its pharmacological activities. The road ahead is to establish specific bioactive molecules, which might be responsible for medicinal properties of this plant. Therefore, the cultivation, collection, phytochemical screening and further pharmacological exploration are essential.

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