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(REVIEW ARTICLE)

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A review on phytochemistry and pharmacological activities of *Schleichera oleosa* (Lour.) Oken

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Abstract

Schleichera oleosa, belonging to the Sapindaceae family, has been reported to possess antimicrobial, antioxidant, anticancer activity, and can be used for the production of biodiesel. The plant contains low tannin levels therefore the plant can be used as fodder for livestock due to the presence of low tannin levels. This species contains some of important phytochemicals such as terpenoids, betulin, betulinic acid, etc. of this plant. This review is focused on the Phytochemistry of the *Schleichera oleosa* along with its pharmacological applications such as antimicrobial, antioxidant, anticancer activity, and can be used for the production of biodiesel.

Keywords: *Schleichera oleosa; Sapindaceae;* Phytochemistry; Anticancer; Antioxidant

1. Introduction

Natural products and traditional medicines are of great importance. Such forms of medicine such as traditional Chinese medicine, Ayurveda and Unani have been practiced in some areas of the world and have been practiced into regular systems of medicine. In the past two years, human attention was increasing on natural products and also in the search for novel drugs in combination with new technology [1].

Schleichera oleosa is a well-known tree of medicinal importance in India. All parts of Kusum are used in Indian Traditional Healing. It is based on Herbal Formulations, which are very popular among the Healers of the present generation, but it is really surprising that very few of the *Schleichera oleosa* based formulations are available in Global Drug Market as promising products [2]. The tree is a rather slow-growing, briefly deciduous tree that can reach a height of 40 meters. The bole, which is usually crooked and slightly buttressed, can be up to 2 meters in diameter.

2. *Schleichera oleosa* (Lour.) Oken

- Botanical Name: *Schleichera oleosa* (Lour.) Oken
- Common Name**:** Ceylon Oak, Kusum Tree, Lac Tree, Gum Lac Tree
- Family: Sapindaceae
- Flowers: The flowers are tiny and hardly noticeable, occurring in short dense yellow clusters.
- Fruit: The fruit is 2.5 to 3 cm long - roughly the size of a small plum and ovoid, 1-3 celled and more or less abruptly tapering to a point, dry indehiscent.

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- Seed: The seed is 1.5 cm long, smooth, brown and enclosed in a succulent aril which has an acidic taste and contains 25-38% oil and up to 22% protein. It is irregular or ellipsoidal in shape, slightly compressed and has a thick brown seed coat on its surface. The moisture in the dried seed should be maintained at around 4-6%.
- Kernel: The kernel is 16-20% in dried fruit, 60-64% in the seed and 51-52% in oil. The kernel is susceptible to fungal attack.

2.1. Distribution

S. oleosa is widely distributed in the sub-Himalayan region, throughout central and southern India, Nepal, Sri Lanka, Thailand, Indonesia and Malaysia. The tree is popularly exploited in India. In Thailand, *S. oleosa* named Ta-Khro is found in the Northern, North-eastern, South-eastern, South-western and Central regions.

2.2. Habitat

This tree grows naturally from the foothills of the Himalayas and the western Deccan Plateau, east to Srilanka, China and Southeast Asia. It grows in Bihar, Central and Southern parts of India. The tree occurs sporadically, seldom gregariously in dry, mixed deciduous forests. It grows in rocky, gravelly or loamy, slightly acidic soil conditions (i.e., well-drained). It is occasionally found in swampy locations, but it usually grows on rather dry soil, at low altitudes, but can be found at 900–1200 meters [3, 4]. The requirement of normal rainfall is 750–2800 mm and an ambient temperature of 35-47.5 °C.

2.3. Plant Morphology

Deciduous trees, 20 m high, bole fluted; bark 10-12 mm thick, surface grey, smooth, brittle; blaze reddish-brown.

Leaves: paripinnate, alternate, exstipulate; rachis 5.5-11.5 cm, stout, glabrous, swollen at base; leaflets 4-6, opposite or subopposite; petiolule upto 3 mm, slender, glabrous; lamina 5-15 x 1.8-4.5 cm, elliptic-oblong, ovate or obovate, base oblique or rarely obtuse, apex acute or obtuse, margin entire, coriaceous, glabrous; lateral nerves 10-23, parallel, prominent, intercostal reticulate, faint.

Flowers: polygamodioecious.

2.3.1. Growing Season

- Flowering and fruiting are from March-June.
- Plants succeed in tropical and subtropical areas, usually at low elevations but sometimes up to 1,200 meters above sea level.
- It grows best in areas where annual daytime temperatures are within the range of 30 – 42 ℃, but can tolerate 10 – 47 ℃
- When dormant, the plant can survive temperatures down to about -4°c, but young growth can be severely damaged at -1 ℃
- It prefers a mean annual rainfall in the range of 1,200 - 2,300mm, but tolerates 750 - 2,800mm.

2.4. Taxonomical Classification [5]

- Kingdom: Plantae
- Phylum: Spermatophyta
- Subphylum: Angiospermae
- Class: Dicotyledonae
- Order: Sapindales
- Family: Sapindaceae
- Genus: *Schleichera*
- Species: *Schleichera oleosa*

2.5. Ethanobotanical Uses [6]

Table 1 Traditional and Ayurvedic Uses of *S. oleosa* [8]

S.no	Parts	Traditional and Ayurvedic Uses
1	Leaves	Feed Stock for Ruminants
2	Barks	Astringent, Dysentry, Menorrhia, Malaria, Febrifuge, Arthalgia
3	Fruit	Anthelmintic
4	Seed and its oil	Rheumatism, Itching, Burns, Promotes hair growth, Alopecia, Cold, Fever, Ear ache, Anthelmintic
5	Aerial Part	Central Nervous System
6	Whole Part	Anti-Diabetic

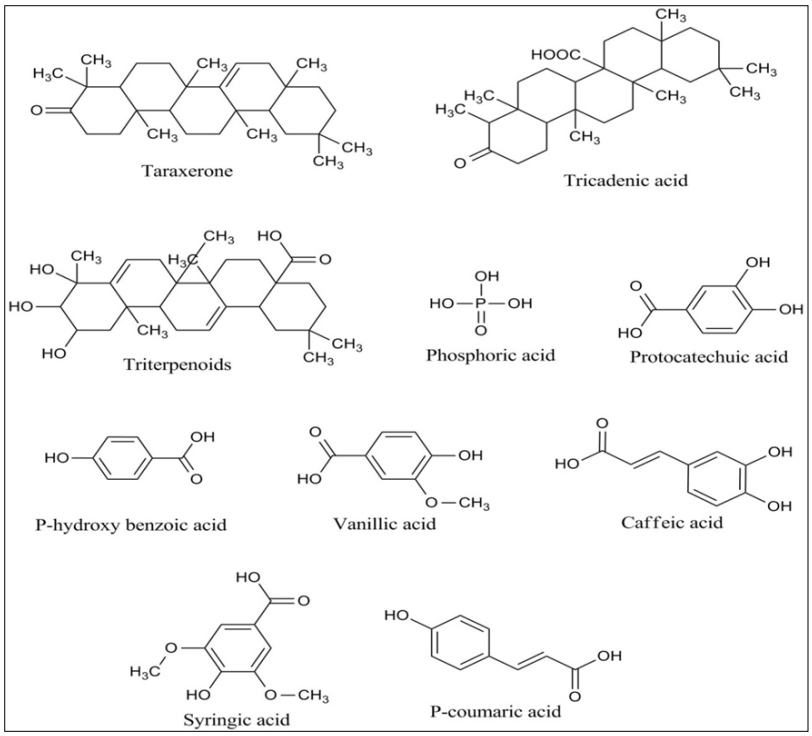

Figure 1 Structures of some of the major phytochemical constituents

Table 2 Major Phytoconstituents Present in *S. oleosa* Tree [5, 9, 10]

Plant Parts	Phytoconstituent
Barks	Taraxerone, Tricadenic acid, Tanin, Resin, Sterols, Triterpenoids
Leaves	Gallo-tannic acid, Crude Protein, Calcium, Phosphorus
Seed	Fatty acid, Phosphoric acid, Cyanogenic glucoside, Protein, Fat, Carbohydrate, Potash
Fruits	Protocatechuic acid, p-hydroxy benzoic acid, Vanillic acid, Caffeic acid, Syringic acid, p-coumaric acid

Different parts of *S. oleosa*, such as fruits, leaves, bark and seeds are used as tribal food, animal feed, seed-oil and timber. The tree also serves as important source for traditional medicines for curing pruritus, malaria, inflammation and ulcers. The past researches has studied the properties of *S. oleosa* extracts from the bark and stem and it was found to reduce the free radicals that cause the death of cancer cells . Antimicrobial activities were also performed against some fungal

and bacterial species [7]. Oil extraction (Kusum oil or Macassar oil) from seed. *S. oleosa* can be used for the cure of itch, acne, skin burns as a massage oil for rheumatic pains solution. The water extract of the bark of *S. oleosa* was used to treat menstrual pain as well.

3. Pharmacological Activities

Due to the presence of both primary and secondary metabolites comprises common sugars, amino acids, proteins, alkaloids, terpenoids, phenolic compounds, flavonoids and tannins in the various parts including stem, root, leaves and seeds, *S. oleosa* exhibit greater biological applications [11, 12]. The various applications of the *S. oleosa* were discussed as follows.

3.1. Anti-inflammatory activity [13, 14]

In the treatment of inflammation several synthetic agents like non-steroidal anti-inflammatory drugs (NSAIDs) of salicylates, aryl anthranilic acid, aryl propionic acid, p-amino phenol derivatives are used widely, but most of the drugs are having severe side-effects and not safer due to the formation of toxic metabolites and, hence, the treatment of this ailment has been shifted to herbal based treatment. Alkaloids, glycosides, terpenoids, resins, phenolic compounds, flavonoids, steroids and fatty acids are the responsible phytoconstituents for the anti-inflammatory activity in plants. The bark of the plant contains tannins and therefore, the possible mechanism of the bark extract is to exert the activity by scavenging free radicals like nitric oxide (NO), produced by nitric oxide synthase which is the second messenger during the process of inflammation. The result shows the inhibition of Nitric oxide Production and reported the anti-inflammatory effect by using alcoholic extract of stem bark of *S. oleosa* (Lour.) Oken

3.2. Analgesic activity [2]

The analgesic activity of alcoholic extract of stem bark of *S. oleosa* (Lour.) Oken was reported against carrageenan-induced paw edema and TPA (tetradecanoylphorbol-13-acetate) induced ear edema in Wister rats and Albino mice. The extracts of 200 mg/kg and 400 mg/kg exhibited promising responses against carrageenan-induced paw edema indicating a significant reduction of paw volume. At the higher dose, the extract showed maximum inhibition of paw edema up to 54.21% when compared to the standard. For the support of the possible mechanism behind the activity, the reduction of tissue levels of nitric oxide and malondialdehyde (MDA) was also reported. In the case of TPA-induced mouse ear edema, the extract exhibited inhibition in a dose-dependent manner. At a higher dose (400 mg/kg) the extract significantly reduced the weight of the ear. Among various inflammatory mediators, *S. oleosa* mainly inhibited 5-HT (5-Hydroxy tryptamine) and PGE2 in a dose-dependent manner as these agents cause inflammation via the arachidonic acid-mediated COX (cyclooxygenase) pathway. The results showed the inhibition of both COX-1 and COX2 by 69.25% and 62.17% respectively.

3.3. Antiulcer activity [15]

All over the World population, 10% of people were affected by ulcers. This disease becomes a major gastrointestinal disorder nowadays. The etiology of this disease is mainly due to *Helicobacter pylori* infection, NSAIDs, stress, diet, etc. In the current scenario, the condition was treated by exhibiting the effect of tannins against *H. pylori* infection. The percolated ethanolic extract of stem barks of the plant *S. oleosa* (Lour.) Oken. was evaluated for antiulcer activity in Wistar albino rats at the dose of 200mg/kg against Omeprazole (2mg/kg) as standard control. The extract was found to be more effective against ulcers, as it provided 60% protection against ulcers. Moreover, the extract was reported better activity and markedly reduced the total volume of gastric acid secretion, gastric acidity and pH of the stomach.

3.4. Anthelmintic activity [2]

The Anthelmintic activity of *S. oleosa* (Lour.) Oken study against the standard drug albendazole was evaluated on earthworms. Eighteen groups, each consisting of six earthworms of about equal size were released into 10 ml of suspension. Each group was treated with one of the following: vehicle standard albendazole (25 mg/ml, 50 mg/ml and 100 mg/ml) and Hydroalcoholic extract of *S. oleosa*. Time taken to paralysis and death of individual worms were observed. The death time was concluded when the worms lost totally their motility followed by fading away of their body colour, *In vitro* investigation results indicated that the *S. oleosa* leaves of plant extract at 100 mg/ml inhibited almost completely the mobility of isolated worms which is comparable with the reference standard drug albendazole. This investigation, therefore, reveals that the hydroalcoholic *S. oleosa* extract was potent at the doses of 25, 50 and 100 mg/ml. The study reported the presence of phenolic compounds in plant leaves showed potent anthelmintic activities.

3.5. Antibacterial and anti-mycoticeffect [7]

Methanolic extract of *S. oleosa*, a timber-yielding plants, was evaluated for preliminary phytochemical screening and antibacterial activity against uropathogenic bacterias. Qualitative phytochemical analysis indicated the presence of alkaloid, resin, tannin, carbohydrate, saponin, flavonoids and anthraquinones, along with, *S. oleosa* exhibited significant antibacterial activity based on minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) among twenty-one plants. Tannins as a Phytoconstituents, inhibit several extracellular bacterial enzymes, affect microbial metabolism by inhibiting oxidative phosphorylation and minimize the availability of essential metal ions by the formation of metal complexes. Flavonoids and alkaloids are also important plant constituents for exerting antifungal and antibacterial activity. Quercetin, a flavonol, has the property to inhibit DNA gyrase. The extracted seed oil (Kusum oil) from *Schleichera trijuga* was reported for antifungal activity and proved to be a significant member to inhibit *Candida albicans* isolated from eye patients. Triterpenoids which have been isolated from the methanolic extract of the outer bark of *S. oleosa* from Darjeeling foothills have significant effects against fungal and bacterial pathogens. Though the exact mechanism of triterpenoids for inhibiting microbial growth hypothesized that these constituents inhibit DNA synthesis in microbes by preventing cell division.

3.6. Anti-Oxidant Activity [2]

Plant constituents like alkaloids, flavonoids, tannins, sesquiterpene have been reported for having their antioxidant activity. The hydroxyl group of flavonoids can donate hydrogen to form stable flavonoids radical by their metal-ion chelating and antiradical properties. Sesquiterpene lactone and alkaloids were also been studied for Fe2+- chelating activity and antiradical properties to evaluate possible mechanism of antioxidant activities. Root extracts of *S. oleosa* (Lour.) Oken. was assayed for free radical scavenging activity with Fenton's reaction generated OH in site-specific and non-site-specific deoxyribose degradation assay. Ethyl acetate extract (67.72%) and methanolic extract (83.38%) exhibited maximum activity in site-specific and non-site-specific assays respectively at 100µg/ml concentration, therefore, the extracts were more potential in metal-ion chelation and in support of result the authors performed plasmid nicking assay to confirm the prevention of DNA damage. The methanolic bark extract of the plant showed maximum inhibitory activity (94.29%) in site-specific assay and in the non-site-specific assay, the ethyl acetate fraction was established as a more potent candidature in a dose-dependent manner. The ethanolic extract of the bark was also reported to have significant free radical scavenging activity which was assayed by DPPH (2,2-diphenyl-1-picrylhydrazyl), hydrogen peroxide and nitric oxide scavenging methods.

3.7. Reproduction enhancement activity [16]

The Reproduction enhancement activity was determined by using an experimental animals such as 30 male Wistar albino rats *(Rattus norvegicus)* weighing 120 – 200g were taken. They were kept in metallic cages (40 x 15 x 16 cm) under laboratory conditions for one week of acclimatization and were divided into five groups. One control group, the second group was treated with a high dose of aqueous leaf extract of *S. oleosa*, the third group was treated with a low dose of aqueous leaf extract of *S. oleosa*, the fourth group was fed with a high dose of methanolic leaf extract and the fifth group was treated with a low dose of aqueous leaf extract. The rats were fed with normal rat chow (guinea feeds product) and tap water. They were kept in a well-ventilated room at ambient temp. of 30 ± 5ºC under 12 hr light / dark cycle. The animals in both control and treated groups were maintained in normal diet while animals in the treated group were administered orally 20 mg / 100 g body weight of methanolic and aqueous leaf extract of *S. oleosa* by using an oral feeding pipe and acute oral toxicity and dose were determined as per OECD-423 guidelines, Rats were separated into groups and the aqueous and methanolic plant extract was fed as per OECD-423 guidelines 329. They were given a normal laboratory pellet diet and water. After 14 days of oral treatment, the blood sample was collected by cardiac puncture in sterilized vials separately for control and treated groups of rats. Samples were analyzed for total RBC count and hemoglobin amount by fully automated bi–directional 5-part differential analyzers technology, The steroid hormone testosterone for *S. oleosa* leaf extracts was measured by radioimmunoassay as mg / mL. Numerical data were expressed as mean ± SD and the results were statistically analyzed. Finally, these study concluded that the prolonged administration of aqueous and methanolic leaf extracts of *S. oleosa* was not toxic and have no altering hematological impacts on Wistar rats. Thus, it may be safe to administer them for various therapeutic purposes. The leaf extracts were finally proven that it has testosterone enhancement quality therefore they can be used in male reproduction enhancement treatments.

Table 3 Phytochemicals present, pharmacological activity, types of extract and method of determination of the Prosopis species

S.no	Part of the plant	Extract	Phytochemicals present	Dose	Activity	Method of determination	Reference
1.	Root extracts of *S. oleosa* (Lour.) Oken.	Ethyl acetate extract (67.72%) and methanolic extract (83.38%)	Phenolic compounds, tannins, fatty acids, resins, hydroxyl-sterols, triterpenoids	100µg/ml concentration	Anticancer Activity	DPPH (2,2-diphenyl-1-picrylhydrazyl), hydrogen peroxide and nitric oxide scavenging methods.	[4]
2.	Root of the Plant	Methanolic and Aqueous Extract	Alkaloids, flavonoids, tannins, triterpenoids, polyphenols, anthocyanins, cholorogenic acids, cyanidine glycosides, quercetins	100mg/kg	Antineoplastic activity	Potent activity against murine P-388 lymphocytic system	[5]
3.	The bark of the plant	Alcoholic extract of stem bark of *S. oleosa* (Lour.) Oken.	Alkaloids, glycosides, terpenoids, resins, phenolic compounds, flavonoids, steroids, fatty acids, tannins	(400 mg/kg)	Analgesic activity	Paw edema and TPA (12-O-tetradecanoylphorbol-13-acetate) andear edema in Wister rats &mice	[7]
4.	The extracted seed oil	Methanolic extract of *S. oleosa*	Alkaloid, resin, tannin, carbohydrate, saponin, flavonoids and anthraquinones	-	Antibacterial	Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)	[7]
5.	Outer bark of *S. oleosa*	Ethanolic extract of *S. oleosa*	Triterpenoids	-	Antifungal activity	Exhibit the potent activity against Candida Albicans	[7]
6.	The bark of the plant	Alcoholic extract of stem bark of *S. oleosa* (Lour.) Oken.	Alkaloids, glycosides, terpenoids, resins, phenolic compounds, flavonoids, steroids, fatty acids, tannins	200 mg/kg and 400 mg/kg	Anti-inflammatory	Paw edema and TPA (12-O-tetradecanoylphorbol-13-acetate) edema in Wister rats and Albino mice	[14]
7.	Stem barks of the plant	Ethanolic extract of the stem bark of *S. oleosa*(Lour.) Oken.	Flavonoids and tannins	200mg/kg	Antiulcer activity	Active potential against *H. Pylori* infection	[15]
8.	Dried plant of *S. oleosa*	Aqueous and methanolic extract	Flavonoids and tannins	20 mg / 100 g	Reproduction enhancement activity	Radioimmunoassay method	[16]

4. Conclusion

*S. oleosa*is a vital medicinal species that is used to treat various diseases. The presence of secondary metabolites namely alkaloids, flavonoids, tannins, triterpenoids, polyphenols, anthocyanins, cholorogenic acids, cyanidine glycosides and quercetins played a greater role in exhibiting significant activity. *S. oleosa* showed unique pharmacological actions

against various diseases. However, further studies are needed to confirm their potential and to determine their effect on human pathogens.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

Author's contribution

All the authors have contributed equally.

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