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Pterospermum acerifolium Linn: Ethnomedicinal uses, phytochemistry and pharmacology: A review

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Abstract
Herbal medicines are the synthesis of therapeutic experiences of generations of practicing physicians of indigenous systems of medicine for over hundreds of years. Herbs have stood the test of time for their safety, efficacy, cultural acceptability and lesser side effects. *Pterospermum acerifolium* Linn is a medicinal herb commonly known as kanakchampa belongs to family Sterculiaceae, which has since long been used in traditional system of medicine for its magical effects to cure various diseases. Traditionally the plant is used as a general tonic, anti tumor agent, analgesic and for the treatment of diabetes, gastrointestinal disorders, leprosy, blood troubles, bronchitis, cough, cephalic pain, migraine and inflammation, small pox and also haemostatic and antimicrobial agent etc. whereas the plant possess beneficial effects such as anti-oxidant, Antinociceptive, antiulcer, hepatoprotective, anti inflammatory, antimicrobial, wound healing, Antimitotic and anticancer activity, Immunosuppressive activity, Anthelmintic activity, Antihyperlipidimic activity and osteogenic activity and many other medicinal properties. This activity of the plant possess due to the important phytochemical constituents like amino acids, sugars, alkaloids, glycosides, tannins, triterpenoids, carbohydrates and flavonoids etc. This review article attempts to highlight the available literature on *Pterospermum acerifolium* with respect to its ethnomedicinal and traditional uses, chemical constituents and summary of its various pharmacologic activities and clinical effects which will helpful to create interest towards future research work and may be useful in developing new formulations with more therapeutic and economical value.

Keywords: *Pterospermum acerifolium*, ethnomedicinal uses, phytochemistry and pharmacological activities

Introduction
Medicinal herbs are used for the prevention and treatment of diseases, and have a long history. However, the most commonly used herbal formulae have no indications of quality, safety and efficacy [1]. It is truth that human being life is not possible without nature. The food, clothes and shelter are three basic necessity of human beings and an important one necessity is good health, which provided by plant kingdom. Plant kingdoms are the rich source of organic compounds, many of which have been used for medicinal purposes. The family Sterculiaceae consists of about 68 genera and 150 species, mostly herbs or shrubs. *Pterospermum acerifolium* (karnikara tree) is an angiosperm indigenous to Southeast Asia, from India to Burma. Traditionally it included in the Sterculiaceae family; however, it is grouped in the expanded Malvaceae family as well[2]. In traditional medicine, there are many natural crude drugs that have the potential to treat many disease and disorders one of them is *Pterospermum acerifolium*; Family: Sterculiaceae popularly known as Kanak champa, Muchkund (Hindi), Muskanda (Bengali), Matsakanda (Telugu), Moragos (Assamese), Vennangu (Tamil), Mushkundo (Oriya), Karnikar (Marathi), Hattipaila (Nepal). An evergreen tree found in the sub-Himalayan tract and outer valleys from Yamuna eastwards to Odisha, West Bengal, and in Assam and Manipur. The present review article provides the highlight of various ethnobotanical and traditional uses as well as Phytochemical and pharmacological reports on *Pterospermum acerifolium*.

Description of *Pterospermum acerifolium*
Pterospermum acerifolium (L) Willd belongs to family: Sterculiaceae is commonly known as "Dinner plate tree" and "Muchukunda". It is a large deciduous tree of about 24 m height and 2.5m girth, with a clean bole up to 12m. Flowers are large 12-15cm, fragrant, white auxiliary, solitary or in pairs, involucral bracts multifid caducous sepals up to 10cm long, linear-oblong, obtus, densely tomentose outside, villous in a broad line within. Petals linear oblong, somewhat obliquely cuneate, slightly shorter than the sepals, staminodes club-shaped.

Ovary oblong, 5-angled, 5-celled, ovules 12-20 in each cell. Capsules 10-15cm long, oblong, 5-angled, clothed outside with furfuraceous pubescence. Leaves are variable in shape and size: 25-35cm by 15-30cm, orbicular, or oblong, entire or variously lobed, chordate and sometimes pelt ate, at length glabrous above, clothed beneath with whitish floccose tomentum, petioles 10-30cm long, terete, tomentose, stipules multifid, caducous. The bark of the trees is smooth grayish brown, young parts clothed with floccose pubescence. Seeds are obliquely ovoid, compressed; wing large, thin. It is widely distributed in North Canada and in many parts India i.e. river banks of sub-Himalayan tracts, Dehradun, West Bengal, Assam and Manipur [3, 4].

Fig 1: Whole plant

Fig 2: Flower

Fig 3: Seed

Fig 4: Bark

Taxonomic position of *pterospermum acerifolium*
Kingdom: Plantae
Division: Magnoliophyta
Class: Magnolipsida
Family: Malvaceae
Subfamily: Sterculiaceae
Genus: *Pterospermum*
Species: *acerifolium*

Ethnomedicinal and traditional uses
Pterospermum acerifolium Linn. has a wide application in traditional system of Indian medicine for example, in ayurvedic anticancer treatment flowers are mixed with sugars and applied locally [5]. Flowers and bark, charred and mixed with kamala applied for the treatment of small pox. Flowers made into paste with rice water used as application for hemicranias [6]. The flowers are used as a general tonic, anti-tumor agent, analgesic and for the treatment of diabetes, gastrointestinal disorders, leprosy, blood troubles, bronchitis, cough, cephalic pain, migraine and inflammation. The leaves and wood are used as haemostatic and antimicrobial agent [7, 8, 9, 10].

Pharmaccgnostical study of *pterospermum acerifolium*
Macroscopic studies
The morphological studies revealed that the wood is yellowish in color with smooth texture and characteristic odour and the leaf is dark green color with a glabrescent texture and characteristic odour. The fresh leaves of *Pterospermum acerifolium* were observed to be with linear Stipules; robust petiole. Leaves are nearly orbicular or oblong, sometimes ± lobed, 24–34 × 14–29 cm, leathery, abaxially densely yellowish and gray stellate velutinous, adaxially hairy or glabrous. Base is cordate with entire crenate margin, truncate apex, nearly rounded, or pointed [11, 12].

Microscopical studies
In the microscopic studies, the leaves showed the presence of long, lignified stellate and four armed trichomes, anomocytic and paracytic stomata, 2 layers of radially elongated palisade cells below upper epidermis, collenchyma, vascular bundles

and spongy parenchyma. The total ash, acid insoluble ash and water-soluble ash values were observed to be 4%, 1.4% and 2.5% respectively and the wood showed presence of uniseriate to biseriate medullary rays of about more than 50 cells high and one to two cells wide, thick walled pitted, arranged in radial rows. Xylem fibers were observed. Vessels are big, found either single or in groups of few. Small polygonal, less thickened xylem parenchymatous cells were observed. Pith was observed at the center. Powder characters showed presence of lignified fibers, calcium oxalate crystals, starch grains and vessel. The total ash, acid insoluble ash and water-soluble ash values were observed to be 3.3%, 1.9% and 1.1% respectively [11, 12].

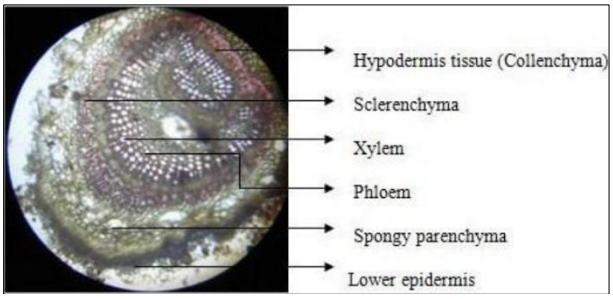


Fig 5: T. S. of leave passing through midrib

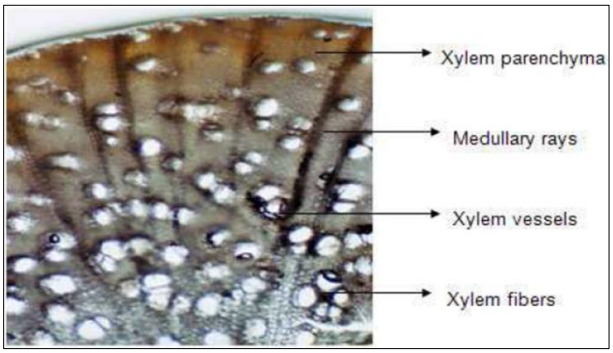


Fig 6: T.S. of *pterospermum acerifolium* wood

Phytochemical constituents [13-25]

Leaves- It contains Flavonoids like Kaemferol-3-o-β-D-galactoside (0.3%) as the major flavonoids, while the other flavonoids were identified as luteolin, luteolin-7- o-β-D-glucoside and luteolin 7-o-β-D-glucuronide. It also contains taraxerol, friedelin, 1-friedelen-3-one and β-sitosterol-3-o-β-D-glucoside.

Flowers

It contains 24-β-ethylcholest-5-in-3-β-O-alpha-cellobioside, 3,7-diethyl-7-methyl-1:5- pentacosanolide, n-hexacosane- 1-26-diol dilignocerate, friedelan-3-alpha- 0l and its beta isomer, n-triacontanol, β-amyrin, β-sitosterol, myristic, palmitic, stearic, arachidic, behenic, lignoceric, oleic, linoleic acids, kaempferol, 4^1-methoxy-kaempferol and kaempferide-7-o-β-D-glucopyranoside. The new constituent of flowers are Pterospermin A [4^1-(2-methoxy-4-(1, 2, 3-trihydroxypropyl)) phenoxy luteolin], Pterospermin B (5, 7, 3^1- trihydroxy-6-o-β-D-glucopyranosyl flavone) and Pterospermin C [3, 5-dihydroxyfuran-2(5H)-one].

Seeds

It contains glycoside in the alcoholic extract of seeds and Seed oil contained malvalic acid as its major cyclopropenoid component and amino acid (tyrosine, cysteine, glycine, alanine) and sugars (lactose, xylose, rhamnose, and glucose). The seeds also contain palmitic, stearic, arachidic, behenic, myristic, lignoceric, oleic, linoleic, and linolenic acids.

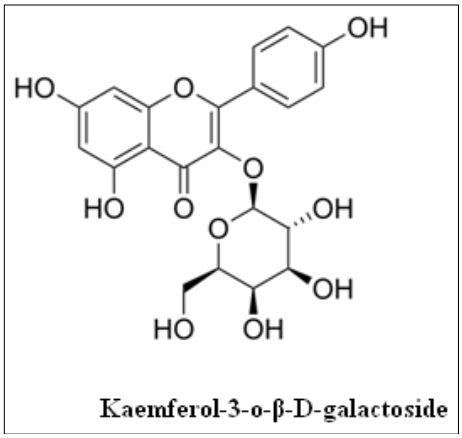
Seed coats

Phytochemical investigation afforded two phytoceramides namely pteroceramide A, pteroceramide B and two acylated phytosterol glucosides namely pterosterol A and pterosterol B.

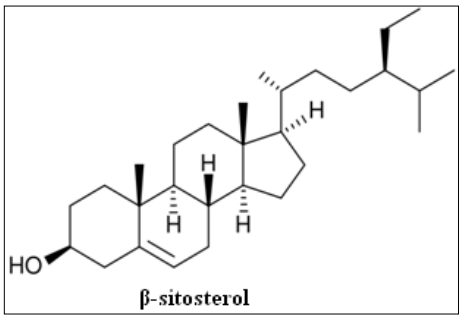
Bark

The bark contains pentadec-11-enoic acid methyl ester, oleanolic acid, β-sitosterol, Kaempferol, kaempferol-3-O-galactoside, luteolin-7-O-glucoside, luteolin-7-O-glucoronide, kaempferide-7-O-beta-D-glucopyranoside, D-galactouronic acid, D-galactose and L-rhamnose. A new polysaccharide (composed of Dgalacturonic acid, D-galactose, and alpha – rhamnose) from the acidic portion. The trunk bark and seeds gave the amino acids tyrosine, cystine, glycine, alanine and leucine.

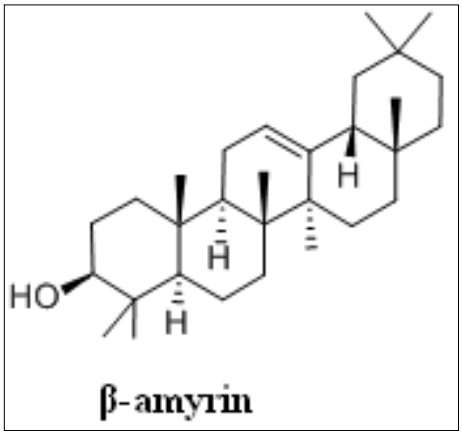
Some important structure of phytoconstitutents



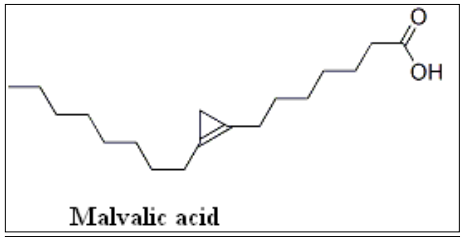
Kaemferol-3-o-β-D-galactoside

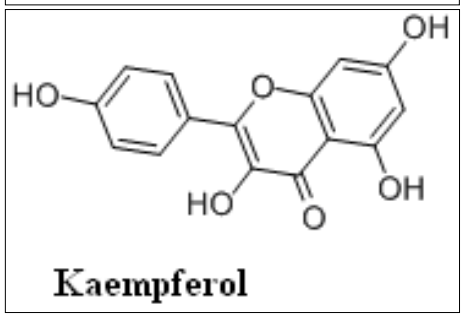


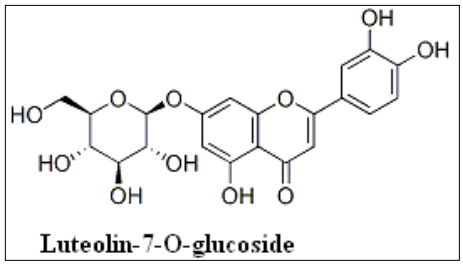
β-sitosterol

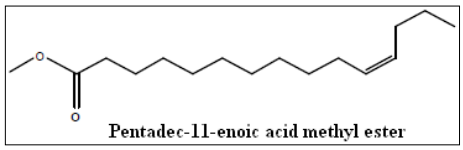


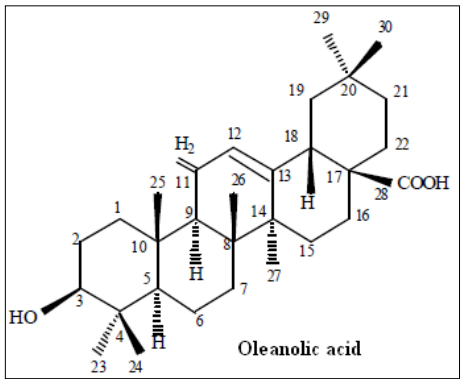
β-amyrin

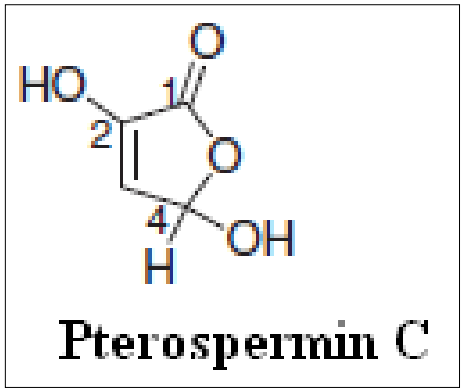


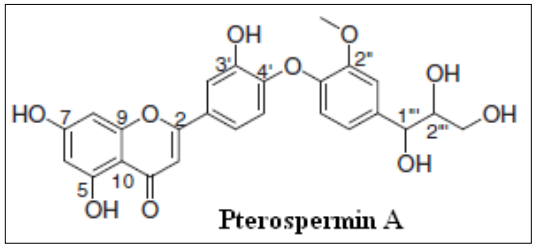


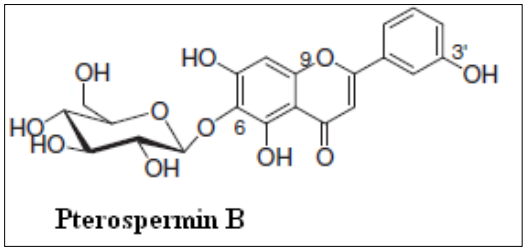


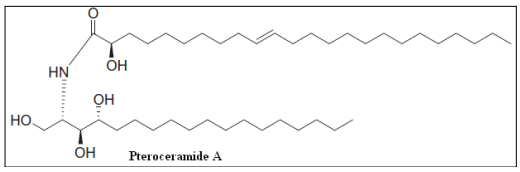


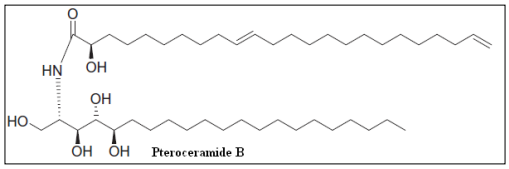












Scientific researches and pharmacological activities

The extensive researches using modern scientific techniques were carried out by various researchers on *Pterospermum acerifolium* since it is believed to be a miraculous herb that can cure multiple ailments and disorders. A number of pharmacological actions of *Pterospermum acerifolium* have been investigated in the past few decades.

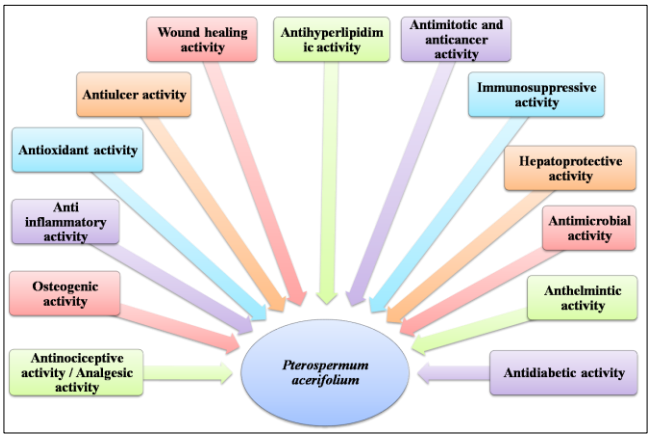


Fig 7: Pharmacological activities

Osteogenic activity

The Phytochemical investigation of seed coats of *Pterospermum acerifolium* afforded two phytoceramides (pteroceramide A, pteroceramide B) and two acylated phytosterol glucosides (pterosterol A and pterosterol B) together with five known compounds. The phytoceramides

and phytosterols glucosides were assessed for their osteogenic activity using primary cultures of osteoblasts harvested from neonatal rat calvaria. By comparison study the phytoceramides markedly stimulated osteoblast differentiation assessed by alkaline phosphatase production and osteoblast mineralization by alizarin red-S staining [24]. The ethanol extracts of the *Pterospermum acerifolium* flowers also showed two new flavones, 4'-(2-methoxy-4-(1,2,3-trihydroxypropyl) phenoxy luteolin and 5,7,3'-trihydroxy-6-O-β-D-glucopyranosyl flavone, and one new lactone, 3,5-dihydroxyfuran- 2(5H)-one along with 14 known compounds. Eight of these compounds pterospermin A, pterospermin B, pterospermin C, trans-tiliroside, linalool-3-rutinoside, (6R, 9S)-3-Oxo-α-ionol-β-D-glucopyranoside, luteolin-7-O-b-glucoside, luteolin-7-β-O-neohesperidoside were assessed for osteogenic activity by using primary cultures of rat osteoblast. From these eight compounds the pterospermin A, pterospermin C and trans-tiliroside significantly stimulated osteoblast differentiation and mineralization as evident from a marked increase in expression of alkaline phosphatase and alizarin red-S staining of osteoblasts [25].

Antinociceptive activity / Analgesic activity

The ethyl acetate soluble part of methanolic extract of *Pterospermum acerifolium* wood (EAPA) possess significant antinociceptive activity against acetic acid-induced writhing test, hot-plate test, paw licking in capsaicin-induced paw licking and sodium chloride induced eye wiping in mice or rats. The antinociceptive activity results indicate that the EAPA acts centrally as well as peripherally and there is involvement of opioid and vanilloid receptors [26]. The ethanolic extract of *Pterospermum acerifolium* bark produced analgesic activity due to the significant inhibition of acetic acid induce writhing and tail clip induced analgesia [27].

Anti-inflammatory activity

The anti-inflammatory activity of ethanolic extract of *Pterospermum acerifolium* bark was studied on different anti inflammatory models. The extract reveals significant anti inflammatory activity against carrageenan induced, mediators induced and arachidonic acid induced rat paw oedema by blocks the histamine and serotonin pathway [27]. The Ethyl acetate fraction of *Pterospermum acerifolium* (EAF) leaves produced significant antiinflammatory activity in both in-vivo and in-vitro model [28]. The methanolic extract of flowers showed significant anti inflammatory activity in both in-vivo and in-vitro studies [43].

Antioxidant activity

Leaves of *Pterospermum acerifolium* L. (Sterculiaceae) are used in India for reducing oxidative stress and inflammation. Antioxidant activity of different fractions were evaluated by using in-vitro antioxidant assays models like determination of total phenolics, DPPH radical scavenging assay, nitric oxide scavenging assay, hydroxy radical scavenging assay and superoxide anion scavenging assay. Ethyl acetate fraction of *Pterospermum acerifolium* (EAF) showed highest free radical scavenging activity in all the models [28]. The Methanolic extract of flower of *Pterospermum acerifolium* (L) Willd showed significant in-vivo anti-oxidant activity. The antioxidant activity of the extract was evaluated by calculating the level of Superoxide dismutase (SOD), Catalase and Malondialdehyde (MDA) [29].

Antiulcer activity

The role of alcoholic fraction of *Pterospermum acerifolium* bark extract on oxidative damages in the gastric tissue during alcohol induced ulceration was investigated and showed significant antiulcer activity against ethanol induced ulceration and as well as significant reduction of tissue lipid peroxidation, catalase, superoxide dismutase and glutathione. Protection rendered by bark extract of *Pterospermum acerifolium* in alcohol induced ulcer is probably due to restoration of superoxide dismutase (SOD) and catalase (CAT) enzyme or due to 5- lipoxygenase antagonism [30]. The ethanolic fraction of *Pterospermum acerifolium* bark extract demonstrated significant antiulcer activity against aspirin, indomethacin & ethanol induced ulcerations, significant inhibition of gastric secretary volume, and total acidity in pylorus ligated rats. The possible reasons of the antiulcer effect of *Pterospermum acerifolium* may be due to (i) the inihibition of 5-LO enzyme (ii) blockade of LTC4, LTD4 synthesis (iii) generation of free radicals; and/or (iv) inhibition of histamine release following mast cell degranulation [31]. The methanolic extract of *Pterospermum acerifolium* produced a significant antiulcer effects when used in combination with famotidine and omeprazole [42].

Wound healing activity

Pterospermum acerifolium, a well-known plant in Indian medicine possesses various therapeutic properties including healing properties and cytokine induction. Wound healing activity of ethanolic extract of *Pterospermum acerifolium* flower along with its effect on tumor necrosis factor-α (TNF-α) was assessed using excision model of wound repair in Wistar albino rats. Treatment of *Pterospermum acerifolium* during wound healing phase the TNF-α level was found to be up regulated. It was concluded that the *Pterospermum acerifolium* has a good wound healing potential. The accelerated healing process and induction of TNF-α by *Pterospermum acerifolium* extract may be the mechanism involved in wound healing process [32]. The studies reveals significant would healing activity of the bark and leaf extract in comparison with providine iodine. The wound healing activity of ethanolic (50% v/v) bark extract and the leaf of *Pterospermum acerifolium* were evaluated by using both excision and incision wound models in rats [33].

Antihyperlipidimic activity

Both doses (250 and 500 mg/ kg body weight) of Methanolic extract of flowers of *Pterospermum acerifolium* showed significant antihyperlipidemic activity in animal experiments following a dose dependent relationship. The extract was evaluated for antihyperlipidimic activity in high fat diet induced hyperlipidemic model in wistar albino rats by measuring the biochemical parameters like Total cholesterol (TC), Low density lipoprotein cholesterol (LDL-C), Very low density lipoprotein cholesterol (VLDL-C), High density lipoprotein cholesterol (HDL-C) and Triglycerides (TGs), Marker enzymes like Alanine transaminases (ALT) & Alkaline phosphatise (ALP), Cardiac risk indicator like Atherogenic ratio and Body weight[29]. *Pterospermum acerifolium* flower can effectively control the blood lipid levels in dyslipidaemic conditions by interfering with the biosynthesis of cholesterol and utilization of lipids. Lipid lowering effect lupeol isolated from of the hydro-alcoholic extract of the *Pterospermum acerifolium* was evaluated in triton and diet induced hyperlipidemic models of Wistar albino rats. The extract (at 400 mg/kg dose level) and lupeol

(20, 40 and 70 mg/kg dose levels) inhibited the elevation in serum cholesterol and triglyceride levels on Triton WR 1339 administration rats. The extract and lupeol at the same dose levels significantly attenuated the elevated serum total cholesterol and triglycerides with an increase in high-density lipoprotein cholesterol in high-fat diet-induced hyperlipidemic rats [34].

Antimitotic and anticancer activity

Pterospermum acerifolium is used traditionally in the management of tumors. Ethanol and Water extracts showed good antimitotic activity against meristamatic cell growth. Both extracts also showed good inhibition on yeast cell growth with IC50 47.88 mg/ml and 39.15 mg/ml respectively. The mode of action of both extract with antiproliferative activity is due to fragmentation effect on DNA [35].

Immunosuppressive activity

The hexane and ethanolic extracts prepared from the seeds of plant *Pterospermum acerifolium* were evaluated for their immunomodulatory activities by exploiting their effects on the humoral and cellular immune arms of BALB/c mice after oral administration for 14 consecutive days at different log doses. Various immune parameters *viz*. lymphoproliferative index, oxidative burst in peritoneal macrophages, modulation in T/B cell population and regulation of Th1/Th2 cytokines in mice were monitored to assess the immunomodulatory characteristics of the plant at 3, 10 and 30 mg/kg doses. Both the extracts exerted remarkable dose-dependent immunosuppressive effect with down-regulation of all the immune markers studied. Administration of extracts in immune-stimulated mice (by treatment with levamisole) further validated the immunosuppressive action [36].

Hepatoprotective activity

The hepatoprotective activity of the ethanol extract of the leaf of *Pterospermum acerifolium* was investigated in rats for carbon tetrachloride induced hepatotoxicity. Administration of Ethanol extract of *Pterospermum acerifolium* leaf extract showed significant hepatoprotective activity against the standard drug silymarin because of the high concentrations of flavonoids [37].

Antimicrobial activity

The antimicrobial activities of *Pterospermum acerifolium* were good against human pathogenic microorganisms, such as *Shigella flexneri, Bacillus licheniformis, Bacillus brevis, Pseudomonas aeruginosa, Streptococcus aureus, Staphylococcus epidermidis, Bacillus subtilis, E. coli*. The result showed that the more anti microbial activity was found with ethyl acetate extracts than the methanol extracts in the form of zone of inhibition [38]. Successive ethanolic extract of bark of *Pterospermum acerifolium* and the fractionated hexane, butanol, methanol and water extract showed antibacterial activity which was tested by using agar cup and minimum inhibitory concentration method against test bacterial species like *S. aureus*, *B. lichenoformis*, *B. subtilis*, *E. coli*, *P. florescence*, *P. aeruginosa*, and *S. typhimurium.* In comparison to all the butanol extract showed maximum activity[40]. Herbal gels containing 15% aqueous *P. acerifolium* seed extract showed anti-bacterial activity for topical use[41].

Anthelmintic activity

The ethyl acetate fraction of all parts of the plants were showing most potent anthelmintic activity because of the phytoconstitutents like flavones and flavonoids, triterpenoids, phenolic compounds and glycosides, but the n-butanol fractions of those parts showed moderate anthelmintic activity, but at higher doses. All other fractions, petroleum extracts and remaining crude extract after fractionations of those three parts of the plant were endowed with minute anthelmintics property, which were not up to standards. The anthelmintic Activity of crude extracts and fractions were investigated against earthworms (*Pheretima posthuma*), roundworms (*Ascardia galli*) and tapeworms (*Raillietina spiralis*) using Albendazole and Piperazine citrate as reference standards. The present study proves the potential usefulness of *Pterospermum acerifolium* in the treatment of helminthiasis [39]. The anthelmintic activity was showed by Petroleum Ether Extract of bark of *Pterospermum acerifolium* on *Pheretima posthuma* against the standard drug Piperazine citrate [36].

Conclusion

In rural communities, the health care system seems that the treatment of disease was entirely managed by herbal remedies before the introduction of modern medicines. Herbs are the natural drugs used to regain the alterations made in normal physiological system by foreign organisms or by any malfunctioning of the body. Now a day's, ethnobotanical and traditional uses of natural compounds, especially of plant origin received much more attention for their efficacy and generally believed to be safe for human use. Thus a detailed and systematic study is required for identification, cataloguing and documentation of plants, which may provide a meaningful way for the promotion of the traditional knowledge of the herbal medicinal plants. The classical approaches in search of new lead molecule for management of various diseases are physiochemical characterization, biological evaluation, toxicity studies, investigation of molecular mechanism of action(s) of isolated phytoprinciple and their clinical trials. The present review summarizes some important pharmacological studies on *Pterospermum acerifolium* and phytochemical investigations and isolated principles from them, which can be investigated further to achieve lead molecules in the search of novel herbal drugs. The pharmacological activities reported in the present review confirm that the therapeutic value of *Pterospermum acerifolium* is much more.

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