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Phyto-pharmacological review of *Sesamum indicum* Linn.

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ABSTRACT

Sesamum indicum L. (Family:Pedaliaceae), plays an important role in ancient culture and modern system of medicine. It is commonly known as sesame or beniseed, is cultivated through out India, mainly for its seeds and oil. The plant traditionally used in the treatment of hemorrhoids, dysentery, constipation, cough, amenorrhea, dysmenorrhea and ulcers. it also produces antifungal, anticancer, antitumor, antiatherosclerotic activity. The total alcoholic extracts of all residual aerial parts of this plant show antioxidant, anticancer, antiaging and anticoagulant activities. In this review, we have explored the phyto-pharmacological properties of *S.indicum* plant and complied its vast pharmacological applications to comprehend and synthesize the subject of its potential image of multipurpose medicinal agent.

KEYWORDS

Sesamum indicum;
Antioxidant;
Sesamolin
Anticancer activity
Vitamin E.

INTRODUCTION

Plants have always been a common source of medicament either in the form of traditional preparations or pure active principles. In survey done by WHO it has been estimated that 80% of more than 4,000 million plants have been used in as traditional medicines for their primary health care needs and also the extracts or the active principles of these plants are used in the traditional therapy[1,2]. Even though the biological active compounds of some herbal drugs or their extracts are unknown, they are prescribed widely because of their effectiveness, minimal side effects in clinical experience and relatively low costs[2].

In India, the plant *Sesamum indicum* Linn. (*Pedialiaceae*) is commonly called Sesame or Beniseed in English, Teel in Hindi, Nuvvulu in Telugu and Nalla Ennai in Tamil, which literal translation in English is 'good oil'. It is also called Gingelly in India[3]. Prior to 600 BC, the Assyrians used sesame oil as a food, salve and medication, primarily by the rich, as the difficulty of obtaining it made it expensive. Hindus use til oil in votive lamps, and consider the oil sacred. According to Hindu belief, lighting lamp filled with til oil in front of Lord Hanuman removes obstacles and difficulties in life[3]. Sesame seed may be the oldest condiment known to man and probably was the first crop grown for its edible oil, which is mainly responsible for its medicinal and industrial products. Ayurvedic practitioners use seed and leaf extracts to treat various disorders[4].

DESCRIPTION

The plant sesame, *Sesamum indicum* L., is a pubescent annual herb, cultivated as weed in various parts of India at sea level[5]. The stem grows upto 1-2m height.

Figure 1 : Whole plant of *Sesamum indicum* Linn.

The herb contains 2 types of hairs; long articulate and short 4-lobed mucilaginous. The leaves are trifoliolate or pinnatisect, upper ones simple, ovate-oblong to lanceolate, 4-20cm long to 15cm wide with petioles 2-15cm long. The flowers are single or sometimes paired in axils, very shortly pedicellate, calyx is pubescent, green, about 6mm long, lobes are sharply acute; corolla is pinkish-purple (rarely white), about 3.6cm long, stamens included. The capsule are erect, oblong, rounded, 4-grooved, pubescent, about 2.5cm long, 2-valved. The seeds are black, brown or white, 2.5-3mm long, smooth or minutely reticulate[6].

Phytoconstituents from *Sesamum indicum*

The sesame seeds by expression yield a fixed oil consisting essentially of the glycerides of oleic and linoleic acids with small preparations of stearin, palmitin and mystirin. The oil is bland in taste and almost odourless. Sesamin, another constituent of the oil, may be obtained in long crystalline needles melting at 118^{o}F, insoluble in water, light petroleum, ether alkaloids and mineral acids, easily soluble in chloroform, benzene and glacial acetic acid. Liquid fatty acids are present to about 70 %, solid fatty acids 12 to 14 %[4].

Sesame seeds contain two unique substances, sesamin and sesamolin occur during refinement the two phenolic antioxidants, sesamol and sesaminol, are formed. Both of these substances belong to a group of special beneficial fibers called lignans, and have been shown to possess cholesterol-lowering effect in humans, and to prevent high blood pressure and increase vitamin E supplies in animals. Sesame seeds are a very good source of copper, and calcium. Just a quarter-cup of sesame seeds supplies 74.0% of the daily value for copper, 31.6% of the magnesium and 35.1% of the daily value for calcium. It is also high in protein, phosphorous, iron and magnesium. Copper is known for reducing pain and swelling of rheumatoid arthritis. Magnesium supports Vascular and Respiratory health. Calcium helps to prevent Colon Cancer and Osteoporosis. The seeds also have a good amount of manganese, iron, phosphorus, zinc, vitamin B1, tryptophan and dietary fibers[7].

Three anthraquinones, named anthrasesamones A, B and C, were isolated from the roots of *Sesamum indicum*, and their respective structures were determined to be 1-hydroxy-2-(4-methylpent-3-enyl) anthraquinone, 1,4-dihydroxy-2-(4-methylpent-3-enyl) anthraquinone and 2-chloro-1,4-dihydroxy-3-(4-methylpent-3-enyl) anthraquinone on the basis of spectroscopic evidence. Other two known anthraquinones are isolated from the roots of *S. indicum* and characterized as 2-(4-methylpent-3-enyl) anthraquinone and (E) 2-(4-methylpent-1,3-dienyl) anthraquinone[4,8].

Some workers has isolated an antimicrobial compound from the hairy roots of Sesamum indicum and identified as 2-isopropenylnaphthazarin-2,3-epoxide, which is actually a homonaphthazarin derivative[9,10]. Some workers isolated a chlorinated red naphthoquinone pigment possessing antifungal activity, named chlorosesamone (2-chloro-5, 8-dihydroxy-3-3methyl-2-butenyl)-1, 4 naphthoquinone), was reported from the roots of *Sesamum indicum*[7,11]. Anthrasesamone is a rare chlorinated anthraquinone in higher plants[4]. The total phytosterol content (400-413mg per 100grams) in sesame seeds in comparison to English walnuts and Brazil nuts (113mg/100gm and 95mg/100gm) were also reported[12].

Several lignans are isolated from *Sesamum* sp.

contain an unusual oxygen insertion between their furano and aromatic rings. As part of ongoing studies to clarify the biosynthetic pathway to the sesame lignans, the furanoketone, (+)-episesaminone, was isolated and fully characterized in part via hemisynthesis from (+)-sesamolin[13]. From water extract of whole plant, two new phenylethanoid glycosides, and three new triglycosides which had the same sugar sequence were isolated[14].

A new lignan glucoside was isolated from defatted sesame seed flour as sesamolinol diglucoside by mass and nuclear magnetic resonancespectroscopy[15]. A quantitative analysis of 65 sesame seed samples showed that sesamolinol diglucoside ranged from 5 to 232mg per 100g of seeds with no difference in white and black seeds[16].

Pharmacological studies of *Sesamum indicum*

Antioxidant activity

Sesame and its components serve as viable natural sources of antioxidants for food and non-food applications[7]. Feeding sesame lignans to rats have shown to reduce Fe^{2+} induced oxidative stress. Compared with those fed groundnut oil, sesame oil-fed rats had lower levels of hepatic thiobarbituric acid-reactive substances, serum glutamate oxaloacetate transaminase (SGOT) activities and serum glutamate pyruvate transaminase (SGPT) activities, indicating protection against Fe-induced oxidative stress i.e. antioxidant action[17,18]. The antioxidant action of aqueous and ethanolic seed extracts from *S. indicum* using various *in vitro* reactive oxygen/nitrogen species (ROS/RNS) generated chemical and biological models. Results demonstrated that the graded-dose (25-1000mg/ml) of aqueous and ethanolic extracts markedly scavenged the nitric oxide, superoxide, hydroxyl, 1,1-diphenyl-2-picrylhydrazyl and 2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) radicals and, showed metal chelating ability as well as reducing capacity in Fe^{3+}/ferricyanide complex and ferric reducing antioxidant power assays. The IC_{50} values of both extracts were compared with respective antioxidant standards. Overall, ethanolic extract of *S. indicum* possess strong antioxidant capacity and offering effective protection against LDL oxidation susceptibility[19]. Bacillus circulans strain YUS-2 was isolated as the strongest antioxidant-producer in fermentation of sesame oil cake (SOC,defatted residue yielded from sesame seed oil production). Two major strong oxidants from fermented SOC were purified and identified as known sesaminol triglucoside and sesaminol diglucoside[20].

Antifungal activity

A red napthaquinone, named hydroxylsesamone, was isolated from the roots of *S. indicum* together with a known yellow naphthoxirene derivative, 2,3-epoxy-2,3-dihydro-5,8-dihydroxy-2-(3-methyl-2-butenyl)-1,4-naphthaquinone, named 2,3-epoxysesamone. The structure of napthoquinone was characterized on the basis of spectral evidence. Chlorosesamone, hydroxysesamone and 2,3-epoxysesamone shows antifungal activity towards Cladosporium fulvum, which was established in a study by Hasan[21].

Anti-cancer activity

Sesame seeds and their lignans have been studied, both directly and indirectly, for possible anticancer effects. Research has shown that the sesamin lignan can be converted by intestinal microflora in humans to the mammalian lignans, enterolactone and enterodiol, which may have protective effects against hormone-related diseases such as breast cancer[22,23]. In one study, the sesamol lignan was found to stop the growth and induce apoptosis (programmed cell death) of cancer cells[24]. A further study in 220 premenopausal women reported that the risk of breast cancer fell with increasing enterolactone concentrations[25]. A possible mechanism by which sesame lignans may arrest cancer growth came to light in a recent study. It was shown that sesamin arrested cell growth in the early phase of the cell cycle called G1, by down-regulating a protein called cyclin D1, which promotes cancer cell growth[26]. Sesame alcoholic extract of flower possess antineoplastic (tumor inhibiting) effect. The effects of alcohol extract from *Sesamum indicum* flower on tumor growth in tumorigenic mouse, and on weight of immune organs showed inhibiting effect on tumor growth and had not distinct effect on weight of thymus and spleen in mice[27].

Allergenic activity

Sesame seed and sesame seed oil have been thought as rare causes of food allergy,representing less than 1% of all food allergy cases. It is reported nine caes of IgE-dependent allergy to sesame seed and sesame seed oil, six of which were diagnosed in 1995 alone[28]. Allergy to sesame seeds often occurs in patients with a simultaneous sensitization to nuts and flour. Previously cross reactions are verified by RAST inhibition. In this study the nature of this cross-reactivity is further characterized by Sodium dodecyl sulfate-olyacrylamide gel electrophoresis and IgE immunoblotting[29]. Allergic reactions induced by ingestion of foods containing sesame seeds, are a well recognized cause of severe food-induced anaphylaxis. Sodium dodecyl sulfate–polyacrylamide gel electrophoresis and IgE immunoblotting were performed on sera of 10 patients selected for severe and documented allergic reaction after eating food containing sesame. The major allergen was purified by gel filtration and characterized by isoelectric point (p*I*), glycosylation and amino acid sequencing. But the results are found to be all the patients had positive IgE antibodies and skin prick tests (SPTs) to sesame. The major, clinically most important allergen was a protein with molecular mass of about 9000. It was not glycosylated, the amino acid sequence showed it was a 2S albumin with a p*I* of 7.3; the small and the large subunits, forming the whole protein, showed p*I* values of 6.5 and 6.0. Later two new sesame seed allergens, Ses i 6 and Ses i 7 was identified[30,31].

Anti-aging activity

Furthermore, another study revealed that sesamin prevents the breakdown of gamma tocopherol in the body, resulting in higher bioavailability of this critical nutrient. In this study, a single dose of sesame oil, containing 136mg of sesame lignans coadministered with gamma tocopherol reduced the urinary excretion of gamma tocopherol and increases both alpha and gamma forms in the body, which is responsible for the anti-aging property[32].

Vasorelaxant activity

The petroleum ether soluble fraction (SIPE) of the root extract of S. indicum was evaluated for the vasorelaxant activity using isolated rat aorta. SIPE up to 180μg/ml concentration significantly inhibited phenylephrine- and KCl-induced contraction to the extent of 98.13+/-6.37 and 70.19+/3.43% respectively in isolated rat aorta in a concentration dependent manner. The vasorelaxant activity was not blocked by propranolol (10μM), atropine (1μM) indomethacin (10μM) and glibenclamide (10μM). Influence of SIPE on phenylephrine-induced contractions in aortic preparations in absence of functional endothelium and on pre-incubating the tissue with L-NAME (300μM) or methylene blue (10μM) was also studied. SIPE at 180μg/ml concentration could elicit partial relaxation in presence of L-NAME or methylene blue to the extent of 34.26+/-6.13 and 25.66+/-10.95% respectively. However, in absence of functional endothelium, SIPE exhibited little relaxation to the extent of 6.70+/-4.87%. These studies revealed that the vasorelaxant activity of SIPE was chiefly mediated through endothelium-dependent pathway[33].

Anti-hyperglycemic activity

The total alcoholic, petroleum ether and n-butanol extracts of aerial residual parts showed a reductive effect on the blood glucose level of diabetic rats. The total alcoholic extract showed a more powerful effect than its fractions. The potency of the total alcoholic extract is 77.4%. Blood sugar reduction may be due to possible inhibition of free radicals and subsequent inhibition of tissue damage induced by alloxan. β-Sitosterol[30] and ferulic acid[25] were reported to possess hypoglycaemic activity. Therefore, they may be responsible at least partly for the hypoglycaemic activity of the alcoholic extract. Taken together, these findings suggest that the alcoholic extract may be useful in alleviating oxidative stress and attenuating the hyperglycemic response associated with diabetes.

Anti-coagulant activity

The total alcoholic extract as well as both of its petroleum ether and *n*-butanol fractions (dose of 100mg/kg body weight) possesses a significant anticoagulant effect. The three extracts increased the time required for coagulation of blood. The total alcoholic extract produces more potential effect. The pronounced activity of each extract leads us to spot light on a new anticoagulant effect of this plant[34].

Hypolipidaemic activity

Flavonoids isolated from *S.indicum* was analysed for its biological activities. Flavonoids from *S. indicum* have hypolipidaemic and hypoglycemic activities as well[35]. These flavonoids were effective in raising the hemoglobin levels in rats[36].

Alters lipid peroxidation

The dietary sesamin and sesaminol, major lignans if sesame seed, elevate the α-tocopherol concentration and decrease the thiobarbituric acid reactive substance (TBARS) concentration, which is the measure of extent of lipid peroxidation. TBARS was lower in the liver and serum of rabbits fed docosahexaenoic acid (DSF) plus cholesterol than in rabbits fed the cholesterol diet. Although wedid not detect sesaminol glucosides in peripheral tissues, we observed abundant quantities of sesaminol in rabbits fed DSF, the principal metabolite. So these sesame lignans decreases the lipid peroxidation as a result of elevated concentrations of α-tocopherol[37,38].

Induces protective mechanism

The effects of ethanolic extract of sesame coat (EESC) on oxidation of low-density lipoprotein (LDL) and production of nitric oxide in macrophages were investigated. The results showed that EESC in the range of 0.01-0.8mg per ml markedly inhibited copper-induced LDL oxidation and H_2O_2-induced cell damage which implies that EESC could exhibit a protective action on biomolecules and generation of inflammatory mediators in vitro[39].

Hypocholesteromic activity

The effect of globulin fraction with a lysine: arginine ratio 0.67, isolated from sesame seeds on cholesterol (CHT) metabolism was studied in rats fed CHT free and CHT containing diet and compare with casein. This suggests that the globulin decreases the CHT level and lowers the lysine: arginine ratios and exert hypocholesteromic effects[40].

Hepatic lipid lowering effect

Sesamin, a sesame seed lignan, has an effect on hepatic fatty acid metabolism by altering the gene expression of the enzyme responsible for it, peroxisomal acyl-CoA oxidase and it decreases the hepatic activity and abundance of fatty acid synthase enzyme. By alterating the fatty acid metabolism it produces lipid-lowering effect[41].

Anti-atherosclerotic activity

Fatty acid composition, antioxidants, and other components such as lignans have major effects on the atherosclerotic process. Sesame oil could inhibit atherosclerosis lesion formation effectively, Because of the synergistic actions of fatty acid antioxidants and nonsaponifiable components[42]. In biological models, both aqueous & ethanolic extracts were found to inhibit metal-induced lipid peroxidation in mitochondrial fractions, human serum and LDL oxidation models. In lipoprotein kinetics study, both extracts significantly ($P<0.05$) increased lag phase time along with reduced oxidation rate and conjugated dienes production. Ethanolic extract of *S. indicum* showed higher amounts of total polyphenol and flavonoid content as compared to their counterpart. The IC(50) values of both extracts were compared with respective antioxidant standards. Overall, ethanolic extract of *S. indicum* possess strong antioxidant capacity and offering effective protection against LDL oxidation susceptibility[43].

Wound healing activity

The seeds of *S. indicum* are used traditionally in the folklore for the treatment of various kinds of wound. Kiran & Asad recently studied the wound healing property of sesame seed and oil in albino rats. Seeds and oil of *S. indicum* possess good wound healing activity when applied locally or administered orally. The low dose of both seeds and oil are more effective when applied locally and the high dose of seeds and oil showed greater effect in dead space wound when administered orally[44].

Neuroprotective effect

Pandit et al studied the neuroprotective Effect of Defatted Sesame Seeds Extract (DSE) against in vitro and in vivo Ischemic Neuronal Damage. For IN VITRO ischemia, oxygen-glucose deprivation followed by reoxygenation (OGD-R, 4 hours OGD followed by 24 hours reoxygenation) in HT22 cells was used to investigate the protective effects on cell death and the inhibitory effects on lipid peroxidation. For IN VIVO ischemia, the middle cerebral artery occlusion (MCAo, 2 h of MCAo followed by 22 h of reperfusion) rat model was used. Twenty-two h after occlusion the rats were assessed for neurobehavioral deficit and infarct volume. DSE (0.1-10μg/mL) significantly reduced the cell death and inhibited lipid peroxidation induced by OGD-R. DSE (30, 100 and 300mg/kg, P.O.) given twice at 0 h and 2 h after onset of ischemia reduced brain infarct volume dose-dependently and improved sensory-motor function. The therapeutic time window of DSE (300mg/kg, P.O.) was 2 h after MCAo in rats. The results of this study show that DSE may be effective in ischemia models by an antioxidative mechanism[45].

Analgesic activity

Recently the analgesic activity of ethanol extract of seeds of S. *indicum* has been studied. It was observed that the extract showed a significant inhibition on the writhing response produced by induction of acetic acid. The intensity of writhing inhibition of the extract was increased with the increase of dose. The extract produced about 48.19 and 75.46% writhing inhibition at the doses of 250 and 500mgkg^{-1}, respectively, which was comparable to the standard drug ibuprofen where the inhibition was about 71.82% at the dose of 25mg kg^{-1}[46].

Functional properties of sesame

The proximate composition and functional properties of full fat and defatted beniseed (*Sesamum indicum* L.) flour were evaluated for foam capacity and stability, water and oil absorption, bulk density, emulsion capacity and nitrogen solubility. Defatting increased the crude protein, ash, crude fiber, carbohydrate and mineral contents. Defatted flour showed comparatively better foam capacity and stability, water absorption and emulsion capacities but diminished bulk density and oil absorption capacity. Nitrogen solubility was pH dependent with a minimum at pH 4 and maximum at pH 8. Maximum nitrogen solubility (95%) was recorded for defatted flour while that for the full fat flour was 60%. The proximate composition and functional properties of the samples suggest that beniseed flour would have useful application in fabricated foods[47].

Ayurvedic applications

The seeds are excellent rejuvenate tonic for bones and teeth; hemorrhoids, dysentery, constipation. The decoction with linseed is used for cough, aphrodisiac as a paste and the dried seed powder used for amenorrhea, dysmenorrheal. Applying the oil to the body and head is useful for calming, giving nutrition, treat ulcers, oozing wounds and eye problems. Ingestion of oil treats gonorrhea. The mucilage of leaves used for dysentery, cholera. The leave decoction blackens hair and promotes hair growth. The oil is also used for massaging purposes[4].

CONCLUSION

The sesame, *S. indicum* was carried out an utmost importance from the ancient time to cure mankind against various disease conditions. These studies play the drug as a novel candidate for bioprospection and drug development for treatment of diseases as cancer, diabetes, atherosclerosis, branchial asthma and various disorders. The medicinal applications of this plant are countless and investigations still remain carries out in relatively newer areas of its function. By the isolation of various phytochemicals and minerals, it enables to exploit its therapeutic use and plays an important role in modern system of medicine.

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