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Bioactivity of *Sesamum indicum*: A review study

Sepide Miraj[1] and Sara Kiani[2*]

[1]*MD, Resident of Obstetrics and Gynecology, Cellular and Molecular Research Center, Shahrekord University of Medical Sciences, Shahrekord, Iran*
[2]*Research Assistant, Cellular and Molecular Research Center, Shahrekord University of Medical Sciences, Shahrekord, Iran*

ABSTRACT

Sesamum indicum (black seasame) is a plant growing and cultivated in Africa, India and Asia including some parts of Iran. This plant was used in Iranian folk medicine for their digestive, carminative, antispasmodic, sedative, analgesic, tonic and diuretic as well as for functional gastrointestinal disorders. The aim of this study was to overview its bioactive properties. This review article was carried out by searching studies in PubMed, Medline, Web of Science, and Iran Medex databases .The initial search strategy identified about 102 *references. In this study, 43 studies was accepted for further screening and met all our inclusion criteria (in English, full text, Antioxidant activity of seasame and dated mainly from the year* 1990 *to 2016).The search terms were "Antioxidant activity, Sesamum indicum, pharmacological activity, chemical compound, alternative medicine. The results of this study was indicated that this plant is commonly used for its antioxidant properties. It showed that Sesaminol inhibited the lipid peroxidation in LDL in a concentration dependent manner. Free radical scavenging capacity, inhibition of low density lipoprotein cholesterol and metal chelating capacity of extracts of sesame seeds was shown that it has high antioxidant activity. These antioxidative components are effective via synergistic action. Antioxidative activity of refined unroasted seed oil is mainly attributed to Sesaminol. Antioxidant agent of sesame was introduced to be related to the Presence of various new antioxidative lignan phenol compounds in sesame seed and oil. Sesaminol as a new antioxidative principle in raw sesame salad oil was introduced. The mechanism of the superior antioxidative activity of roasted sesame oil was associated to its synergistic effect of the browning products with tocopherol, sesamol, and sesamin. Seasame is widely used for its antioxidant activities that trigger its significant value. Various combinations and numerous medicinal properties of its seed, oil, cake, coat demand further and more studies about the other useful and unknown properties of this multipurpose plant.*

Key words: bioactive activity, Antioxidant activity, seasame, pharmacological activity, chemical compound, alternative medicine

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INTRODUCTION

Sesame [*Sesamum indicum*] is an annual plant , belong to Pedaliaceae family [1], is a herbaceous plant cultivated for its edible seed, oil and flavorsome value [2]. It is known as "Queen of Oilseeds" due to its high degree of resistance to oxidation and rancidity.it is native to Africa and India. This plant grow 50 to 100 cm tall, while its leaves grow 4 to 14 cm long[3]; The flowers are yellow and tubular. The flowers may vary in color, with some being white, blue, or purple. Sesame seeds are also colored including white, buff, tan, gold, brown, reddish, gray, and black. Sesame fruit is a capsule, normally pubescent, rectangular in section, and typically grooved with a short, triangular beak [4]. Sesame seeds are small. Their size, form, and colors vary with the thousands of varieties .The seed coat may be smooth or ribbed [5-7]. Sesame is consumed directly as sweetmeat, a “peanut butter-like” product, a candy ingredient, bread condiments, and snack foods.

Traditionally, sesame seeds were used in Hindu culture as a "symbol of immortality" and its oil was used widely in prayers and burial ceremony.it was used in traditional Middle Eastern cooking. The nutritious seed cake is used as animal feed and sesame flour[8].Sesame oil is largely used in southern and Chinese cooking.

Recently, it is used for its usefulness for the liver, kidney, spleen and stomach. Its high oil content not only lubricates the intestines, but nourishes all the internal viscera. It is also known to blacken the hair, especially the black sesame. Hence, it is applied to white hair, habitual constipation and insufficient lactation. Sesame oil is also helpful in treating intestinal worms such as ascaris, tapeworm, etc.

Sesame seeds contain up to 55% oil and 20% protein. Sesame proteins consisted of lysine, tryptophan and methionine. Sesame oil is rich in linoleic and oleic acids, the predominance of gamma-tocopherol over the other isomers of vitamin E and high content of fat-soluble lignans [sesamin and sesamolin][9]**.**Sesame oil is constituted 50% of compound of this herb, which is highly resistant to oxidation, and 25% protein, which has a unique balance of amino acids[10].Sesame seed contain vital minerals, vitamins, phytosterols, polyunsaturated fatty acids, tocopherols and unique class of lignans such as sesamin and sesamolin Sesame seed is high in protein, vitamin B1, dietary fiber as well as an excellent source of phosphorous, iron, magnesium calcium, manganese, copper and zinc . In addition to these important nutrients, sesame seeds contain two unique substances, sesamin and sesamolin. Both of these substances belong to a group of special beneficial fibers called lignans[sesamin, sesamolin, sesaminol and sesamolinol]. Sesame seed also contains lignan aglycones in oil and lignan glucosides. Sesame seed is rich in oil, contains high amounts of [83-90%] unsaturated fatty acids, mainly linoleic acid [37-47%], oleic acid [35-43%], palmitic [9-11%] and stearic acid [5-10%] with trace amount of linolenic acid. [6] The seeds are a rich source of antioxidants and bioactive compounds including phenolics, phytosterols, phytates, PUFA and short chain peptides. Sesame cake is a rich source of protein, carbohydrate and mineral nutrients. Sesame seeds have special significance for human nutrition on account of its high content of sulfur amino acids and phytosterols[11].

This herb is said to be rich in polyunsaturated fatty acids and natural antioxidants, sesamin, sesamolin and tocopherol homologues.Recent studies on the antioxidant and anti-carcinogenic activities of sesame seed have greatly increased its applications in health food products that assert for liver and heart protection and tumor prevention[12].

MATERIALS AND METHODS

Chemical constituent

Sesame seeds contain thelignans, sesamolin,sesamin, pinoresinol andlariciresinol[13].Insoluble 11S globulin and soluble 2S albumin, conventionally termed α-globulin and β-globulin, are the two major storage proteins and constitute 80−90% of total seed proteins in sesame[14].Comparison of amino acid composition indicated that they were substantially less hydrophobic than the known oleosins, and thus should not be aggregated multimers of oleosins. The results of immuno-recognition to sesame proteins revealed that these three polypeptides were unique proteins gathered in oil bodies, accompanying oleosins and triacylglycerols, during the active assembly of the organelles in maturing seeds[15]. The phospholipid , oleic and linoleic acids, chlorophyll and sesamolin , sesamol and γ-tocopherol was found[16]. 10 compounds [2-furfurylthiol, 2-phenylethylthiol, 2-methoxyphenol, 4-hydroxy-2,5-dimethyl-3[2H]-furanone, 2-pentylpyridine, 2-ethyl-3,5-dimethylpyrazine, acetylpyrazine, [E,E]-2,4-decadienal, 2-acetyl-1-pyrroline and 4-vinyl-2-methoxy-phenol] were quantified . On the basis of high OAVs in oil, especially 2-acetyl-1-pyrroline [roasty], 2-furfurylthiol [coffee-like], 2-phenylethylthiol [rubbery] and 4-hydroxy-2,5-dimethyl-3[2H]-furanone [caramel-like] were elucidated as important contributors to the overall roasty, sulphury odour of the crushed sesame material[17].The structures of novel sesaminol glucosides isolated from sesame seed were determined to be sesaminol 2′- O-β-d-glucopyranoside, sesaminol 2′-O-β-d-glucopyranosyl [1→2]-O-β-d-glucopyranoside and sesaminol 2′-O-β-d- glucopyranosyl [1»2]-*O*-[β-d-glucopyransyl [1»6]]-[β-d-glucopyranoside[18].

Mechanism of action

The antioxidative agents [sesamin, sesamolin, sesamol, their glucosylated forms sesaminol glucosides and tocopherol make the oil very stable and therefore it has a long shelf life[19].Antioxidant properties of sesame fractions are related to lignans, an innate non-enzymatic antioxidant defense mechanism against reactive oxygen species which play a vital role in health promotion. The main antioxidant agent of sesame are Tocopherols. They are a class of plant phenolics that have important antioxidant and nutritional properties[20].they are natural antioxidants that inhibit oil oxidation. They have free radicals scavenging properties. The main function of α-tocopherol is that of a radical-chain breaking antioxidant in membranes and lipoproteins, as well as in foods[21].Other tocols are still capable of exerting antioxidant and biological activities in spite of low plasma concentrations. Among the tocopherols, α-tocopherol is the predominant form in the photosynthetic tissues such as stems and leaves. Γ-tocopherol is the major tocopherol in sesame seeds, whereas α-and δ-tocopherols are present in smaller amounts. It is more potent than α-tocopherol in decreasing platelet aggregation, low density lipid [LDL] oxidation and delaying intra-arterial thrombus formation. The amount of γ-tocopherol in sesame ranges from 468.5 to 517.9 mg kg^{-1} lipid while α-and δ-tocopherols are present at low levels. Γ-tocopherol to be 490-680 mg kg^{-1} sesame oil. While it was 210-320, 750 and 800 mg kg^{-1} sesame oil, respectively in wild species, *S. alatum*, *Sesamum angustifolium* and *Sesamum latifolium*.

The antioxidant activity

The total phenolic content, total antioxidant status, free radical scavenging capacity, inhibition of low density lipoprotein cholesterol and metal chelating capacity of extracts of whole black and whole white sesame seeds and their hull fractions in 80% aqueous ethanol were investigated. Results was found that Sesame products displayed good ferrous ion chelating capacities. besides, it was demonstrated that there was a considerable antioxidant activity of sesame products especially black sesame hulls[22].The antioxidant activity of ethanolic extracts of sesame coat was investigated. The antioxidant activity of 1.0 mg EESC was equal to 1.0 mg tocopherol but was weaker than 1.0 mg butylated hydroxyanisole on peroxidation of linoleic acid. EESC showed an inhibitory effect against the formation of thiobarbituric acid reactive substances in a liposome model system. Besides, phenolic compounds and tetranortriterpenoids indicating antioxidant activity, are present in EESC. Result showed that antioxidant activity of this plant is due to its free radical reaction, metal-binding ability and quenching of reactive oxygen [23].Sesaminol extracted from acetone extract of sesame seed.it was shown that sesamolin in unprocessed sesame oil is the source of seaseminol. Sesaminol was not so greatly removed by the deodorization process. The antioxidative activity of Sesaminol was relatively equal to those of sesamol and γ-tocopherol by the thiocyanate method. Therefore, it seems that the antioxidative activity of refined unroasted seed oil is mainly attributed to Sesaminol[24].The effective components of mashed sesame seed with acetone was investigated. The acetone extract showed strong antioxidative activity with the thiocyanate method and offer 4 active antioxidative substances as P1, P2, P3 and P4. The antioxidative activities were in the order of P3 >P2>P1 >P4. The same components were also obtained from the 80% ethanol extractable polar fraction of the sesame oil cake treated with *β*-glucosidase, which suggested the presence of the active substances also as their glycosides in sesame seed[25].

Chemical constituents of sesame oil from two different colored seed varieties were examined. These antioxidative components are effective via synergistic action. Results indicated that both USM and RSM had antioxidant activity in a dose-dependent manner. Compared to USM, the RSM was a better antioxidant in most cases. this could be used as an alternative natural antioxidant for food applications[26].

Differences between two different varieties [cv. *Orhangazi* and cv. *Cumhuriyet*] of *Sesamum indicum* in growth parameters, lipid peroxidation, antioxidative enzyme activities and proline accumulation were tested. Results indicated that both parameters differ according to the ability of the variety in coping oxidative stress caused by salinity. Antioxidative activity of both variety were almost the same. however, the antioxidant enzyme activity of cv. *Cumhuriyet* was more when subjected to salt stress.[27].

In a study antioxidant agent of sesame was introduced to be related to the Presence of various new antioxidative lignan phenol compounds in sesame seed and oil. Sesaminol as a new antioxidative principle in raw sesame salad oil was introduced. The mechanism of the superior antioxidative activity of roasted sesame oil was associated to its synergistic effect of the browning products with tocopherol, sesamol, and sesamin[28].

The antioxidative activity of the crude extract of lignan glycosides obtained from unroasted defatted black sesame seeds was investigated in this study and it was shown that Fr2 and Fr3 showed better antioxidative activity and the main constituents were found to be lignan glycosides and some unknown brown materials. Besides, the brown materials exhibited exceptional DPPH free radical scavenging effect, whereas the identified sesaminol triglucoside in Fr2 and sesaminol diglucoside in Fr3 possess no such activity. Seaminol triglucoside and sesaminol diglucoside showed no effect on the extension of lag phase, while the brown materials had excellent inhibitory effect on the oxidation of LDL. Furthermore, natural antioxidants such as γ-tocopherol, sesamol and sesaminol were not detected in the crude extract of lignan glycosides. Our findings suggest that the brown materials present in Fr2 had a significant contribution to the antioxidative activity of the crude extract of lignan glycosides. thus, further studies are needed to diagnose their nature[29].

Antioxidative constituents of unroasted and roasted sesame seed oil were investigated. The main active constituent in fresh unroasted seed oil was *γ*-tocopherol, and that of roasted seed oil was sesamol, which was produced by hydrolysis of sesamolin that is present to a large degree in roasted sesame seed oil. This conversion of sesamolin to sesamol is catalyzed by acids[30].

Resveratrol, sesamol, sesame oil and sunflower oil are known natural dietary components with intrinsic cancer and antioxidant activities. Comparatively, sesame oil was the most potent followed by sesamol and then resveratrol. Only sesamol and resveratrol showed a remarkable cytotoxic activity in the brine shrimp lethality assays as well as profound free radical scavenging activity in the DPPH bioassay[31].

In an animal study,The effects of sesamin on hepatic fatty acid oxidation were examined in rats that were fed experimental diets containing various amounts of sesamin for 15 days. Dietary sesamin increased oxidation rates in a dose-dependent manner. Mitochondrial activity almost incease 2-fold in rats on the 0.5% sesamin diet. Peroxisomal activity became10 times more in rats fed a 0.5% sesamin diet in relation to rats on the sesamin-free diet [32].

Sesame cake was extracted with methanol to obtain a crude antioxidant extract. Its antioxidant activity was evaluated using the β-carotene bleaching method, linoleic acid peroxidation method and free radical scavenging assay, using 2,2-diphenyl-1-picryl hydrazyl radical. Results showed that crude extract was effective at 100 and 200 ppm levels and comparable with butylated hydroxy toluene at 200 ppm, whereas purified extract showed comparable or better activities at 5, 10, 50, 100 and 200 ppm levels[33].

Antioxidant activity of methanolic extract of sesame cake was evaluated. Results indicated that sesame cake extract, in vegetable oils, could significantly lower the peroxide value, diene value and *p*-anisidine value of oils at 5, 10, 50 and 100 ppm levels during storage at 60 °C. The study also indicated a better antioxidant effect for sesame cake extract than BHT at 200 ppm[34].

In a study, it was suggested that Consumption of moderate amounts of sesame seeds significantly increase plasma γ-tocopherol and alter plasma tocopherol ratios in humans and elevated plasma γ-tocopherol and enhanced vitamin E bioactivity[34].

In an animal study, it was indicated that sesame seed lignans enhance vitamin E activity in rats fed a low α-tocopherol diet and cause a marked increase in α-tocopherol concentration in the blood and tissue of rats fed an α-tocopherol-containing diet with sesame seed or its lignans[35].

The effects of drought on growth, protein content, lipid peroxidation, superoxide dismutase, peroxidase , catalase and polyphenol oxidase were studied in leaves and roots of two speies of *Sesamum indicum* L and it showed that lipid peroxidation was lower in Yekta than in Darab 14. Severe stress increased antioxidant activities in leaves and roots, especially in Yekta[36].

The free radical scavenging capacity of antioxidants from sesame cake extract was studied.

The k_2 values of the sesame antioxidants were compared with those of butylated hydroxytoluene and α-tocopherol. The k_2 values were shown that sesamol, sesamol dimer, sesamin, sesamolin, sesaminol triglucoside, and sesaminol diglucoside had the lowest to the highest degree.

In a vitro study, antioxidant properties of Sesaminol was investigated. Sesaminol inhibited the lipid peroxidation in LDL in a concentration dependent manner .besides, findings suggest that sesaminol is a potentially effective antioxidant that can protect LDL against the oxidation[37].

the antioxidant activities of lignans and tocopherols as well as the browning reaction and its products in sesame seed and/or its oil was reviewed in a study and It is concluded that the composition and structure of browning reaction products and their impacts on sesame ingredients need to be further studied to better explain the remaining mysteries of sesame oil[38].

Antioxidant activity of N-acetylcysteine [NAC] and sesame oil was investigated and NAC supplementation presented significant antioxidant capacity by means of preventing serum lipid status alterations, hepatic damage, and HPA axis disturbance due to high-cholesterol feeding in middle-aged mice. Results showed a beneficial preventive action of plant-derived antioxidants, such as NAC, on lipid metabolism and on the HPA axis[39].

In an animal study, the antioxidant potential and tumor necrosis factor alpha-[TNF-α] inhibiting activity of sesame oil against acute doxorubicin-induced cardiotoxicity was investigated.

The chronic oral administration of sesame oil prevents acute doxorubicin-induced cardiotoxicity by enhancing cardiac endogenous antioxidants and decreasing myocardial TNF-α expression[40].

We investigated the protective effect of sesame oil against nutritional steatohepatitis in mice and it was concluded that sesame oil protects against steatohepatitic fibrosis by decreasing oxidative stress, inflammatory cytokines, leptin and TGF-β1[41].

We investigated the location of radical in various sesame seeds .the 2D imaging of the irradiated white sesameseeds showed that free radicals were located throughout the entire seed. New type of imaging showed the exact location of radical species in various sesameseeds[42].

the effects of sesame butter versus sesame oil on the serum levels of glucose, lipid profile, and oxidative stress biomarkers in diabetic rats was investigated and it showed that the diabetic groups treated with sesame butter and sesame oil had significantly lower levels of glucose and higher levels of high-density lipoprotein than did the diabetic control group [$P<0.05$]. Sesame butter supplementation also increased TAC and decreased MDA concentrations significantly in the diabetic rats [$P<0.05$].The antihyperglycemic, antioxidative, and partly lipid-lowering effects of sesame butter make it an excellent candidate for future human studies on diabetes, although further research is needed to determine the exact dose and duration of supplementation[43].

The efficacy of sesame oil in controlling Osteoarthritis pain in rats was investigated and it was shown that Sesame oil significantly decreased joint pain compared with positive control group in a dose-dependent manner. Sesame oil decreased lipid peroxidation in muscle but not in serum. Besides, it was concluded that daily sesame oil supplement may attenuate early joint pain by inhibiting Nrf2-associated muscular oxidative stress in OA rat model[44].

the effect of sesame oil Shirodhara [SOS] against warm water Shirodhara [WWS] on improving sleep quality and quality of life [QOL] among persons reporting sleep problems was tested and it was shown that SOS may be a safe potential treatment to improve sleep quality and QOL in persons with sleep problems[45].

The effects of sugarcane dietary fiber [SDF] and pre-emulsified sesame oil for pork fat replacement on batter characteristics was evaluated. Replacing pork fat with SDF and pre-emulsified sesame oil significantly affected color, water- and fat-binding properties, texture, dynamic rheology, microstructure and sensory analysis.[46].

The protective and antioxidant potential of sesame oil [SO] and [or] alpha-lipoic acid [ALA] against DZN toxicity in male Wistar albino rats was investigated. DZN-treated animals exhibited macrocytic hypochromic anemia .SO and [or] ALA supplementation ameliorated the deleterious effects of DZN intoxication. Results showed that Seasame oil can reduce the side effects of DZN through their antioxidant and free radical-scavenging activities[47].

The efficiency of tertiary butyl hydroquinone [TBHQ] as an antioxidant in sesame oil [sesamum indicum] by density, viscosity and ultrasonic velocity was investigated. It was concluded that sesame oil with 200 ppm TBHQ can be used for frying without adverse effect on physical properties[48].

In a study, the non-lipid, aqueous components associated with SO would have tested to whether have anti-inflammatory and antioxidant effects. These results suggest the presence of potent anti-inflammatory and antioxidant compounds in sesame oil aqueous extract [SOAE]. Furthermore, SOAE differentially regulated expression of scavenger receptors and increased ATP-binding cassette A1 [ABCA1] mRNA expression through activating liver X receptors [LXRs] [49].

Potential side effects
There are possibility of allergies to sesame Oil, the limit of sensitivity should fall to 5 p.p.m(50).

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