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Antioxidant potential and health benefits of cumin

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Abstract
Cumin (*Cuminumcyminum*) is an important and popular spice locally known as 'zeera' that is used for culinary purpose due to its special aromatic effect. Cumin is a traditional and much used spice from Middle Ages because it was an icon of love and fidelity. The proximate analysis of the cumin seeds reveals that they contain fixed oil, volatile oils, acids, essential oils, protein and other elements. Cumin contains some important components such as pinene, cymene, terpinene, cuminaldehyde, oleoresin, thymol and others that have shown their efficacy against various diseases. It is an important source of energy, strengthens immune system, gives protection against many diseases.The total phenolic content of methanolic extracts of different cumin varieties (cumin, black cumin and bitter cumin) range from 4.1 to 53.6 mg/g dry weight. In this comprehensive review, focus is on the nutritional, antioxidant and pharmacological properties of cumin.

Keywords: Antioxidant potential, health benefits, locally known

Introduction
Spices have been known for ages as effective therapeutic food. The power of spices to impart biological activity is now slowly reemerging as an area of interest for human health. The seed spices constitute an important group of agricultural commodities and play a significant role in our national economy. The cropscovered as major seed spices are coriander, cumin, fennel and fenugreek, whereas ajowan, dill (sowa), celery, nigella (kalonji), caraway (siahjeera) and anise constitute minor group of seed spices (Rathore *et al*. 2013) [18]. Cumin (*Cuminumcyminum*) seeds (Figure 1) are obtained from the herb *Cuminumcyminum*, native from East Mediterranean to South Asia belonging to the family Apiaceae-a member of the parsley family. Cumin seeds are oblong and yellow-grey. Cumin seeds are liberally used in several cuisines of many different food cultures since ancient times, in both whole and ground forms. In India, cumin seeds have been used for thousands of years as a traditional ingredient of innumerable dishes including kormas and soups and also form an ingredient of several other spice blends. Besides food use, it has also many applications in traditional medicine. In the Ayurvedic system of medicine in India, cumin seeds have immense medicinal value, particularly for digestive disorders. They are used in chronic diarrhoea and dyspepsia. Black seed (also known as black cumin; *Nigella sativa*) (Figure 1) is an annual flowering plant belonging to the family Ranunculaceae and is a native of Southern Europe, North Africa, and Southwest Asia. Black cumin is cultivated in the Middle Eastern Mediterranean region, Southern Europe, Northern India, Pakistan, Syria, Turkey, Iran, and Saudi Arabia. *Nigella sativa* seeds and their oil have a long history of folklore usage in Indian and Arabian civilization as food and medicine (Yarnell and Abascal, 2011) [28]. The seeds of *N. sativa* have a pungent bitter taste and aroma and are used as a spice in Indian and extensively in Middle Eastern cuisines. The dry-roasted *nigella* seeds flavour curries, vegetables, and pulses. Black seeds are used in food as a flavouring additive in breads and pickles. It is also used as an ingredient of the spice mixture (*panchphoron)* and also independently of many recipes in Bengali cuisine. Cumin was traditionally used as a preservative in mummification in the ancient Egyptian civilization. Black cumin has a long history of use as medicine in the Indian traditional system of medicine like Unani and Ayurveda (Sharma *et al.* 2005) [20].

Fig 1: Different varieties of Cumin

Cumin (*Cuminumcyminum*) is a flowering plant in the family Apiaceae, native from the east Mediterranean to East India. In India cumin is known in as 'jeera' or 'jira' and in Iran it is called 'zira'. Indonesians call it 'jintan' (or jinten) and in China it is called 'ziran' but in Pakistan it is known as 'zeera' (Nadeem *et al*, 2003). Cumin is a herbaceous annual plant, with a slender branched stem 20-30 cm tall. The leaves are 5-10 cm long, pinnate or bipinnate, thread-like leaflets. The flowers are small, white or pink, and borne in umbels. The fruit is a lateral fusiform or ovoid achene 4-5 mmlong, containing a single seed. Cumin seeds are similar to fennel and anise seeds in appearance, but are smaller anddarker in color (Jazani *et al*. 2008) [8]. The English cumin was derived from the French cumin, which was borrowed indirectly from Arabic 'Kammon' via Spanish 'comino' during the Arab rule in Spain in the 15th century. The spice is native to Arabic-speaking Syria where cumin thrives in its hot and arid lands (Nadeem *et al*. 2003).

Nutrition

Cumin seeds are nutritionally rich; they provide high amounts of fat (especially monounsaturated fat), protein, and dietary fibre. Vitamins B and E and several dietary minerals, especially iron, are also considerable in cumin seeds. Cuminaldehyde (Figure 2), cymene, and terpenoids are the major volatile components of cumin (Bettaieb *et al.* 2011) [3].

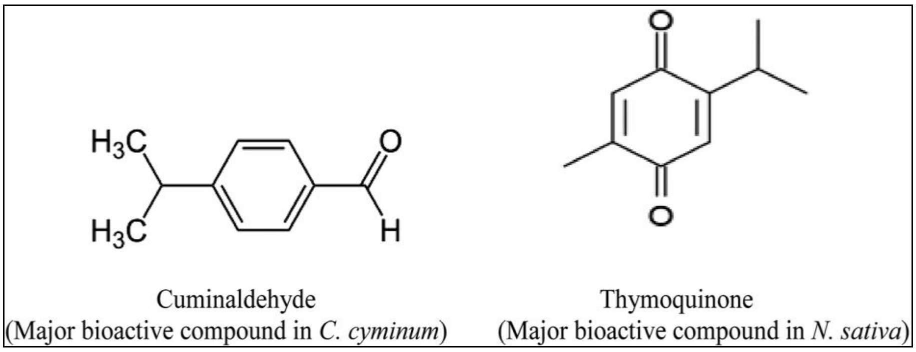

Fig 2: Major bioactive compounds of cumin and black seeds.

Cumin has a distinctive strong flavour. Its warm aroma is due to its essential oil content. Its main constituent of aroma compounds arecuminaldehyde and cuminic alcohol. Other important aroma compounds of roasted cumin are the substituted pyrazines, 2-ethoxy-3-isopropylpyrazine, 2-methoxy-3-sec-butylpyrazine, and 2-methoxy-3-ethylpyrazine. Other components include γ-terpinene, safranal, *p*-cymene, and β-pinene (Li and Jiang, 2004) [13].

Cumin essential oil contents

The most important chemical component of cumin fruits is essential oil content, ranging from 2.5% to 4.5% which is pale to colorless depending on age and regional variations. The ripe seeds of cumin are used for essential oil production, both as whole seeds or coarsely ground seeds. If freely alcohol-soluble oil is required, the whole seed must be used. Hydro distillation is used for essential oil extraction, producing a colorless or pale yellow oily liquid with a strong dour. The yield for oil production varies from 2.5 to 4.5%, depending on whether the entire seed or the coarsely ground seed is distilled. In a study, the essential oil composition of cumin seeds after subjecting them to heating by microwaves and conventional roasting at different temperatures was studied. The conditions were standardized in both methods. The volatile oils distilled from these samples were analysed by GC and GC-MS. The results indicated that the microwave-heated samples showed better retention of characteristic flavor compounds, such as aldehydes, than did the conventionally roasted samples (Behera *et al.* 2004) [2]. Jalali-Heravi *et al.* (2007) [7] used Gas chromatography–mass spectrometry to characterize the essential oil components of Iranian cumin. A total of 19 components were identified by direct similarity searches for cumin oil. This number was extended to 49 components, with the help of chemometrictechniques. Major constituents in cumin are gamma-terpinene (15.82%), 2-methyl-3-phenyl-propanal (32.27%) and myrtenal (11.64%). In addition to volatile oil cumin also contains nonvolatile chemical components including tannins, oleoresin, mucilage, gum, protein compounds and malates. The oleoresins are obtained by subjecting the ground cumin to different organic solvents such as nhexane, ethanol, methanol etc. The extract obtained is then subjected to rotary evaporation to remove the solvent (Peter, 2001) [17]. Kanakdande *et al.* (2007) [10] studied the microencapsulations of cumin oleoresin by spray drying using gum arabic, maltodextrin, and modified starch and their ternary blends as wall materials for its encapsulation efficiency and stability under storage. The microcapsules were evaluated for the content and stability of volatiles, and total cuminaldehyde, γ-terpinene and p-cymene content for six weeks. Gum Arabic offered greater protection than maltodextrin and modified starch, in general, although the order of protection offered was volatiles > Cuminaldehyde > p-cymene > γ-terpinene. A 4/6:1/6:1/6 blend of gum arabic/maltodextrin/modifiedstarch offered a protection, better than gum arabic as seen from the t1/2, i.e. time required for a constituent to reduce to 50% of its initial value. However protective effect of ternary blend was not similar for the all the constituents, and followed an order of volatiles > p-cymene > Cuminaldehyde > γ-terpinene.

Antioxidative properties of cumin

Cumin has also been tested for its antioxidative properties. The total phenolic content of methanolic extracts of different cumin varieties (cumin, black cumin and bitter cumin) ranged from 4.1 to 53.6 mg/g dry weight. Cumin (*Cuminumcyminum*) methanol extract was found to contain a total phenolic content of 9 mg/g dry weight. It has been also shown that the methanolic extracts of cumin show higher antioxidant activity compared with that of the aqueous extract (Thippeswamy and Naidu, 2005) [25]. In another study the antioxidant activity and the phenolic compounds of 26 spice extracts including cumin was assessed. Antioxidant activity was expressed as TEAC (mmol of trolox/100 g of dry weight). Cumin showed a value of 6.61 mmol of trolox/ 100 g of dry weight while the total phenolic content of cumin was 0.23g of gallic acid equivalent/ 100 g of dry weight (Shan *et al.* 2005) [19]. The antioxidant capacity of cumin (*Cuminumcyminum*) has been tested on Fe2+ ascorbate induced rat liver microsomal lipid peroxidation, soybean lipoxygenase dependent lipid peroxidation and 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging methods. The total phenolic content of methanolic extract of cumin was 9 mg/ g dry weight. IC50 values of the methanolic extract of cumin seeds were 1.72±0.02, 0.52±0.01 and 0.16±0.30 on the lipoxygenase dependent lipid peroxidation system, the DPPH radical scavenging system and the rat liver microsomal lipid peroxidation system, respectively. The data also showed that cumin is a potent antioxidant capable of scavenging hydroxy, peroxy and DPPH free radicals and thus inhibits radicalmediated lipid peroxidation (Thippeswamy and Naidu, 2005) [25]. In another study the antioxidant activity and the phenolic compounds of 26 spice extracts including cumin was assessed. Antioxidant activity was expressed as TEAC (mmol of trolox/100 g of dry weight). Cumin showed a value of 6.61 mmol of trolox/ 100 g of dry weight while the total phenolic content of cumin was 0.23g of gallic acid equivalent/ 100 g of dry weight (Shan *et al.* 2005) [19].

Digestive Stimulant Action

In the context of cumin seeds being claimed in home remedies and traditional medicine, to aid digestion, an animal study has examined whether they have any stimulatory effect on the digestive enzymes. The influence of cumin seeds on the digestive enzymes of the rat pancreas and intestinal mucosa has particularly been investigated as a result of both continuous dietary intake and single oral administration (Platel and Srinivasan, 1996; 2000a). Dietary (1.25%) cumin lowered the activity of pancreatic lipase, whereas the activitiesof pancreatic trypsin, chymotrypsin, and amylase were significantly enhanced by the same (Platel and Srinivasan, 2000a). When given as asingle oral dose, cumin exerted a lowering effect on pancreatic lipase, amylase, trypsin, and chymotrypsin. Among the terminal digestiveenzymes, a small intestinal maltase activity was significantly higher in animals fed with cumin, whereas lactase and sucrose were unaffected (Platel and Srinivasan, 1996). Dietary cumin had a significant stimulatory effect on bile flow rate, the extent of increase in bile volume being 25 per cent, whereas its single oral dose did not have any effect on bile secretion rate (Platel and Srinivasan, 2000b). Dietary intake of cumin had a profound influence on bile acid output (quantity secreted per unit time), bile acid secretion being as high as 70 per cent over the control. Similar significant increases in bile acid secretion were seen in the case of cumin when administered as a single oral dose. Since bile juice makes a significant contribution to the overall process of digestion and absorption, essentially by supplying bile acids required for micelle formation, it is expected that cumin, which has a digestive stimulant action, could do so by stimulating biliary secretion of bile acids. Another study has examined whether this digestive stimulant spice cumin also affects the duration of residence of food in the gastrointestinal tract of experimental rats (Platel and Srinivasan, 2001). Cumin produced a significant shortening of the food transit time by 25 per cent. The reduction in food transit time produced by dietary cumin roughly correlates with their beneficial influence either on digestive enzymes or bile secretion.

Antidiabetic Effects

The antidiabetic effect of cumin seeds has been reported in humandiabetics (Karnick, 1991) [12]. In this study, 80 patients' withnon-insulin dependent diabetes mellitus were orally administered for24 weeks with an Ayurvedic formulation containing *C. cyminum*. Fasting and post-prandial blood sugar at 6-week intervals wassignificantly reduced in all the patients. Dietary cumin seeds wereobserved to alleviate diabetes-related metabolic abnormalities in STZ-diabetic rats (Willatgamuwa *et al.* 1998) [27].

Anti-inflammatory effects

Cumin essential oil was investigated for the anti-inflammatory effects in lipopolysaccharide (LPS)-stimulated RAW 264.7 cells and the underlying mechanisms (Wei *et al.* 2015) [26]. Volatile constituents were identified in essential oil using Gas Chromatography-Mass Spectrometry (GC-MS), the most abundant constituent being cuminaldehyde (48.8%). Cumin oil exerted anti-inflammatory effects in LPS-stimulated RAW cells through inhibiting NF-κB and mitogenactivated protein kinases suggesting its potential as an anti-inflammatory agent (Srinivasan *et al*. 2018) [22]

Cardio-protective influence through hypolipidemic and hypotensive effects

*Cuminumcyminum*is traditionally used for the treatment of indigestion and hypertension. The anti-hypertensive potential of aqueous extract of cumin seed and its role in arterial-endothelial nitric oxide synthase expression, inflammation, and oxidative stress have been evaluated in renal hypertensive rats (Kalaivani *et al.* 2013) [9]. Cumin administered orally (200 mg/kg body) for 9 weeks improved plasma nitric oxide and reduced the systolic blood pressure in hypertensive rats. This was accompanied by the up-regulation of the expression of induciblenitric oxide synthase (iNOS), Bcl-2, TRX1, and TRXR1 and downregulation of the expression of Bax, TNF-α, and IL-6. These data suggest that cumin seeds augment endothelial functions and ameliorate inflammatory and oxidative stress in hypertensive rats (Kalaivani *et al.* 2013) [9]

Gastroprotective Effect

The anti-ulcer potential of *N. sativa* aqueous suspension on gastric ulcers experimentally induced with various noxious chemicals (indomethacin, 80% ethanol, and 0.2 M NaOH) in Wistar rats was examined (Al Mofleh *et al.* 2008) [1]. *Nigella sativa* significantly prevented gastric ulcer formation induced by necrotizing agents by significantly replenishing the depleted gastric wall mucus content and gastric mucosal non-protein sulfhydryl concentration. The antiulcer effect of *N. sativa* was exerted through its antioxidant and anti-secretory activities (Al Mofleh *et al.* 2008) [1]. Both *N. sativa* (2.5 and 5.0 ml/kg, p. o.) and TQ (5, 20, 50, and 100 mg/kg, p. o.) were found to possess gastro-protective activity against gastric mucosal injury induced by ischemia or reperfusion in Wistar rats (El-Abhar *et al.* 2003) [4]. Lipid peroxidation and lactate dehydrogenase, elevated by the ischemia or reperfusion insult and decreased glutathione and activity of SOD accompanied by an increased formation of gastric lesions, were countered by *N. sativa* or TQ treatment, indicating their gastroprotective effect, probably by conservation of the gastric mucosal redox state (Srinivasan *et al*. 2018) [22].

Pulmonary-protective activity and anti-asthmatic effects

Nigella sativa has been investigated for the possible beneficial effects on experimental lung injury in rats after pulmonary aspiration (Kanter, 2009) [11] and found that *N. sativa* treatment inhibits the inflammatory pulmonary responses. *Nigella sativa* therapy resulted in a significant reduction in the activity of iNOS and an increase in surfactant protein D in the lung tissue of different pulmonary aspiration models. It is concluded that *N. sativa* treatment might be beneficial in lung injury that merits potential clinical use. The ameliorative effect of *N. sativa* oil in rats with hyperoxiainduced lung injury has also been reported (Tayman *et al.* 2012) [23].

Chemopreventive Effects

Cancer chemopreventive potentials of dietary 2.5 and 5.0 per cent cumin were evaluated against benzo (α) pyrene-induced tumorigenesis in forestomach and 3-methylcholanthrene (MCA)-induced tumorigenesis in uterine cervix in mice (Gagandeep *et al*. 2003) [5]. Cumin produced a significant inhibition of stomach tumour. The effect on carcinogen/ xenobiotic metabolizing phase I and phase II enzymes, antioxidant enzymes, and lipid peroxidation in the liver was also examined. Cytochrome P450 and cytochrome b5 were significantly augmented bydietary cumin. The phase II enzyme glutathione-S-transferase (GST) was increased by cumin, whereas the specific activities of superoxide dismutase (SOD) and catalase were significantly elevated. Lipid peroxidation was inhibited by cumin, suggesting that the cancer chemopreventive potential of cumin could be attributed to its ability to modulate carcinogen metabolism.

The anti-cancer effect of *N. sativa* has extensively been studied in different *in vitro* and *in vivo* models. *Nigella sativa* is ableto exert antioxidant, anti-mutagenic, cytotoxic, pro-apoptotic, antiproliferative, and anti-metastatic effects in various primary cancercells and cancer cell lines (Majdalawieh and Fayyad, 2016). The available studies strongly suggest that *N. sativa* could serve as an effectiveagent to control tumour initiation, growth, and metastasis independently or in combination with conventional chemotherapeutic drugs. *Nigella sativa* extract ameliorated the benz (α-) pyreneinduced carcinogenesis in the forestomach in mice (ArunaandSivaramakrishnan, 1990). This is partly attributed to the ability to influence phase II enzymes. Orally administered *N. sativa* oil (14 weeks) interfered with the induction of aberrant crypt foci (ACF) by 1, 2-dimethylhydrazine, putative preneoplastic lesions for colon cancer in rats (Salim and Fukushima, 2003). This inhibition may be associated, in part, with the suppression of cell proliferation in the colonic mucosa. *Nigella sativa* aqueous suspension significantly prevented gastric ulcer formation experimentally induced by necrotizing agents and also significantly ameliorated the severity of ulcer and gastric acid secretion in pylorus-ligated Shay rats (Al Mofleh *et al*. 2008) [1].

Immunomodulatory Action

The immunomodulatory properties of *N. sativa* and its major active ingredient, TQ in terms of their experimentally documented abilityto modulate cellular and humoral adaptive immune responses have comprehensively been reviewed (Majdalawieh and Fayyad, 2015) [14]. The molecular and cellular mechanisms underlying such immunomodulatory effects of *N. sativa* and TQ are highlighted, and the signal transduction pathways implicated in the immunoregulatory functions are suggested. Experimental evidence suggests that *N. sativa* extracts and TQ can therapeutically be employed in the regulation of immune reactions in infectious and non-infectious conditions such as allergy, autoimmunity, and cancer. The potential immunomodulatory effects of aqueous extract of *N. sativa* investigated in BALB/c mice and C57/BL6 primary cellswith respect to splenocyte proliferation, macrophage function, and anti-tumor activity demonstrated that *N. sativa* significantly enhancessplenocyte proliferation in a dose-responsive manner (Ghonime *et al.* 2011) [6].

Conclusion

The overall evaluation of this review concludes that cumin has a good antioxidant potential. The essential oils present in this spice have high antioxidant activity and its nonvolatile extracts also have good inhibition properties against the free radicals. Multiple studies made in the last decades validate its health beneficial effects particularly in diabetes, dyslipidemia, hypertension, respiratory disorders, inflammatory diseases, and cancer. These seeds also possess immune stimulatory, gastroprotective, hepatoprotective, nephroprotective, and neuroprotective activities. Therefore, this study concludes that cumin in addition to its use as a flavoring agent, has good antioxidant potential and has many with health benefits as well.

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