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# *Cuminum cyminum* and *Carum carvi*: An update

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## Abstract

*Cuminum cyminum* and *Carum carvi* are the sources of cumin and caraway seeds respectively, which have been used since antiquity for the treatment of various indications in traditional healing systems in wide geographical areas. Cumin and caraway seeds are rich sources of essential oils and have been actively researched for their chemical composition and biological activities. In recent times (especially during the last 3 years) considerable progress has been made regarding validation of their acclaimed medicinal attributes by extensive experimental studies. In this attempt many novel bioactivities have been revealed. This review highlights the significance of cumin and caraway as potential source of diverse natural products and their medicinal applications.

**Keywords:** *Caraway*, *Carum carvi*, *cumin*, *Cuminum cyminum* chemistry, pharmacology

## INTRODUCTION

*Cuminum cyminum* and *Carum carvi*, belonging to the family Apaiaceae, are one of the earliest cultivated herbs in Asia, Africa and Europe. Cumin and caraway seeds from *Cu. cyminum* and *Ca. carvi*, respectively, have remained popular as culinary spices and are also overwhelmingly used in folklore therapy since antiquity in diverse geographical areas [Figure 1a, b]. The aromatic substances present in these herbs have attracted enormous attention of researchers worldwide to experimentally validate the therapeutic uses of cumin and caraway seeds, which are documented in several indigenous healing systems. This review attempts to highlight the recent investigations in which diverse pharmacodynamic actions of cumin and caraway seeds overwhelmingly support their acclaimed medicinal attributes in traditional medicines.

## ETHNOMEDICAL/FOLKLORE USAGE

Ayurveda is an ancient Indian therapeutic system, which is based on the curative properties of plants and plant derived products. A very large number of medicinal herbs of various taxonomic genera are included in many forms in this traditional therapy, which are also relied upon in other other indigenous systems of medicine practiced in Southeast Asia, such as Siddha and Unani systems. In these traditional therapies, cumin as well as caraway seeds are prominently considered carminative, eupeptic, antispasmodic, astringent and used in the treatment of mild digestive disorders, diarrhea, dyspepsia, flatulence, morning

sickness, colic, dyspeptic headache and bloating, and are said to promote the assimilation of other herbs and to improve liver function. They have also been used in bronchopulmonary disorders and as a cough remedy, as well as an analgesic. Vapors from caraway seeds are reported to give relief in patients suffering from lumbago and rheumatism. Caraway water finds use as a vehicle for pediatric medicines. As a mixture with alcohol and castor oil, it has been used for the treatment of scabies.[1–4]

In fact, medicinal usage of cumin and caraway seeds has also been immensely widespread in diverse ethnomedical systems from Northern Europe to the Mediterranean regions, Russia, Iran, Indonesia and North America, where these have remained as an integral part of their folk medicines. In Iranian traditional medicine, cumin is considered stimulant, carminative and astringent and its therapeutic effects have been described on gastrointestinal, gynecological and respiratory disorders, and also for the treatment of toothache, diarrhea and epilepsy.[5] In the Moroccan traditional medicine, caraway seeds are used as diuretics[6] and given to treat diabetes and hypertension.[7]

In traditional medicine of Tunisia, cumin is considered abortive, galactagogue, antiseptic, antihypertensive herb , while in Italy, it is used as bitter tonic, carminative, and purgative.[8] In indigenous Arabic medicines, the seeds are documented as stimulant, carminative, and attributed with cooling affect and therefore form an ingredient of most prescriptions for gonorrhea, chronic diarrhea and dyspepsia; externally, they are applied in the form of poultice to allay pain and irritation of worms in the abdomen. Seeds reduced to powder, mixed with honey, salt and butter are applied to scorpion bites.[9] In Poland, caraway is recommended as a remedy to cure indigestion, flatulence, lack of appetite, and as a galactagogue. In Russia, it is also used to treat pneumonia. In Great Britain and USA, it is regarded a stomachic and carminative. In Malay Peninsula, caraway is one important medicinal herb, and in Indonesia, it is used in the treatment of inflamed eczema.[10]

## CHEMICAL COMPOSITION

In the recent past, exploration of chemical composition of cumin and caraway seeds (which are also rich sources of essential oils) has remarkably captured enormous attention of researchers. In the quest to identify the constituents, a diverse array of compounds have been revealed in essential oils, oleoresins and seeds of carum and caraway that have grown in diverse agro-climate locations. Majority of such compounds are monoterpene hydrocarbons, oxygenated monoterpenes, oxygenated sesquiterpenes, saturated and unsaturated fatty acids, aldehydes, ketones and esters.[11–40] The other components which occur in caraway seed are fatty acids, triacylglycerols, polysaccharides, and lignin.[41–46] From these studies, it has emerged that the major compounds occurring in caraway are carvacrol, carvone, α-pinene, limonene, γ-terpinene, linalool, carvenone, and *p*-cymene, whereas the major compounds occurring in cumin are cuminaldehyde, limonene, α- and β-pinene, 1,8-cineole, *o*- and *p*-cymene, α- and γ-terpinene, safranal and linalool.

In aqueous and solvent derived seed extracts, diverse flavonoids, isoflavonoids, flavonoid glycosides, monoterpenoid glucosides, lignins and alkaloids and other phenolic compounds have been found.[24,47–52] Roots of caraway have also been found to contain flavonoids.[53] The seed and root of caraway showed the presence of polyacetylenic compounds.[54] In a recent study, a nonspecific lipid transfer protein has been isolated from the cumin seed.[55] Several nutrients (vitamins, amino acids, protein, and minerals), starch, sugars and other carbohydrates, tannins, phytic acid and dietary fiber components have also been found in cumin seeds.[19,56–60]

The surge for investigating chemical constituents in cumin and caraway has remained equally matched with the attempts to evaluate their biological activities in many collateral studies. About 30 independent experimental investigations on the chemistry and biology of cumin and caraway seeds were documented in

2009–2010.

## BIOLOGICAL AND PHARMACOLOGICAL ACTIVITY

### Antioxidant

Cumin and caraway products (oils as well as their aqueous and solvent derived extracts) have shown significant antioxidant activity in several test methods. These effects are documented as their ability to prominently quench hydroxyl radicals, 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals and lipid peroxides. The other assays employed were ferric thiocyanate method in linoleic acid system, $Fe^{2+}$ ascorbate-induced rat liver microsomal lipid peroxidation (LPO), soybean lipoxygenase dependent lipid peroxidation and ferric reducing ability.[13,16,18,20,39,53,58,61–70] A caraway root extract has also shown significant anti-DPPH radical activity.[53] The cumin and caraway oils exhibited high antioxidant activity which has been attributed largely to the presence of monoterpene alcohols, linalool, carvacrol, anethole and estragol, flavonoids and other polyphenolic compounds.[16,53,67,71,72] The antiradical profile of cumin and caraway has been proposed as the underlying mechanism for their multifaceted pharmacological properties such as antimicrobial, antidiabetic, anticarcinogenic/antimutagenic, antistress, antiulcerogenic, etc. as outlined in the succeeding sections.

### Antimicrobial

Numerous investigations have revealed a potential antimicrobial activity of cumin and caraway products (oils as well as their aqueous and solvent derived extracts). This antibacterial action was assessed against a range of useful and pathogenic gram-positive and gram-negative bacterial strains. [16,20,21,23,26,38,69,73–79] Cumin seed oil and alcoholic extract inhibited the growth of *Klebsiella pneumoniae* and its clinical isolates and caused improvement in cell morphology, capsule expression and decreased urease activity. This property was attributed to cuminaldehyde [Figure 2a].[80,81 Biofilm-formation preventive properties were found against *Streptococcus mutans* and *Streptococcus pyogenes*. [81,82]

The ability of caraway oils to inhibit the growth of fungi and bacteria is attributed to carvone, limonene and linalool, whereas limnonene, eugenol, -pinene and some other minor constituents have been suggested to contribute to the antimicrobial activity of cumin oil.[83–86] The antibacterial activity of carvacrol (5-isopropyl-2-methylphenol) [Figure 2b] is amply documented in various experimental studies and is suggested to be in synergism with its precursor *p*-cymene.[87]

Antifungal activity of cumin and caraway oil is recorded against soil, food, animal and human pathogens, including dermatophytes, *Vibrio* spp., yeasts, aflatoxins and mycotoxin producers.[16,21,31,88–94] Carvacrol (from caraway oil) proved most active against *Penicillium citrinum*.[88]

### Anticarcinogenic/antimutagenic

In independent studies, dietary supplementation of both cumin and caraway was found to prevent the occurrence of rat colon cancer induced by a colon-specific carcinogen, 1,2-dimethylhydrazine (DMH). In cumin receiving animals, no colon tumors were observed. The excretion of fecal bile acids and neutral sterols was significantly increased, and cumin was shown to protect the colon and to decrease the activity of β-glucuronidase and mucinase enzymes. β-glucuronidase increases the hydrolysis of glucuronide conjugates and liberates the toxins, while the increase in mucinase activity may enhance the hydrolysis of the protective mucins in the colon. Histopathological studies also showed lesser infiltration into the submucosa, fewer papillae and lesser changes in the cytoplasm of the cells in the cumin-treated colon. In cumin-treated rats, the levels of cholesterol, cholesterol/phospholipid ratio and 3-methylglutaryl COA-

reductase activity were reduced.[95–96] Dietary supplementation of caraway also showed similar preventing action. It attenuated DMH-induced histopathological lesions and suppressed aberrant crypt foci development, while decreasing the levels of fecal bile acids, neutral sterols, and tissue alkaline phosphatase activities.[97–98] Dietary cumin inhibited benzopyrene-induced forestomach tumorigenesis, 3-methylcholanthrene induced uterine cervix tumorigenesis, and 3-methyl-4-dimethyaminoazobenzene induced hepatomas in mice. This was attributed to the ability of cumin in modulating carcinogen metabolism via carcinogen/xenobiotic metabolizing phase I and phase II enzymes. Activities of cytochrome (CYP) P-450 reductase and CYP b5 reductase were augmented, whereas phase II enzymes GST and DT-diaphorase were increased.[99–100] Solvent derived seed extract of caraway reversed 2, 3, 7, 8-tetrachlorodibenzo-*p*-dioxin (TCDD) induced mutagenicity. It inhibited TCDD induced CYP 1A2 activity and CYP 1A1 activities and expression in rat hepatoma cells in a dose-dependent manner.[101] CYP P-450 1A1 is considered to convert xenobiotics and endogenous compounds to toxic and/or carcinogenic metabolites, and its suppression is implicated in the prevention of cancer caused by chemical carcinogens.

In these studies, the attenuation of carcinogenicity by cumin and caraway has been attributed to their potential antioxidative action in the target tissues.[98,100] After caraway treatment along with carcinogens like DMH, 3- methylcholanthrene, and benzopyrene, the levels of intestinal, colonic and cecal lipid peroxidation products (conjugated dienes, lipid hydroperoxides and thiobarbituric acid reactive substances) were decreased, while the activity of superoxide dismutase (SOD), catalase, GSH-reductase, and the level of reduced glutathione (GSH) were augmented. Monoterpenes like anethofuran, carvone, and limonene occurring in cumin and caraway oil have specifically been highlighted for anticarcinogenic action.[40,98,102–105]

Many studies have related the anticarcinogenic actions of cumin and caraway to their potential apoptotic, antimutagenic and antiproliferative properties. The apoptotic activities of caraway ethanol extract are reported against several human cancer leukemia cell lines.[106] Methanol extracts of caraway showed antiproliferative activity in tumor cell lines MK-1, HeLa and B16F10. These chemopreventive and antiproliferative actions have been suggested to be due to bioactive polyacetylenic compounds and other monoterpenes, anethofuran, carvone, and limonene.[40,54] Aqueous and solvent derived caraway extracts have shown protective effect against several mutagens such as N-methyl-N′-nitro-N-nitrosoguanidine (MNNG), dimethylnitrosamine, nitrosodimetlyamine, methylazoxymethanol acetate, methylated/ethylated nitrosourea, and methyl and ethylmethane sulfonates, in *Salmonella typhimurium* and other test strains.[107,108] This activity was attributed to carvone content which was found to inhibit the development of diethylsitosamine-induced stomach cancers in mice.[40,104,105] The cumin and caraway were devoid of any inherent mutagenic potential.[56]

### Antidiabetic

The antidiabetic effects of cumin and caraway products are amply documented.[109] In a glucose tolerance test conducted in rabbits, cumin significantly increased the area under the glucose tolerance curve and hyperglycemic peak.[110] A methanolic extract of cumin seeds reduced the blood glucose and inhibited glycosylated hemoglobin, creatinine, blood urea nitrogen and improved serum insulin and glycogen (liver and skeletal muscle) content in alloxan and streptozotocin (STZ) diabetic rats.[111,112] The collateral benefits included decreased creatinine, urea nitrogen and improved insulin and glycogen in tissue and skeletal muscles, accompanied by a reduction in rat tail tendon collagen-linked fluorescence and pepsin digestion which are implicated in the pathogenesis of diabetic microvascular complications.[112] In another study, an aqueous extract of cumin prevented *in vitro* glycation of total soluble protein, α-crystallin, and delayed the progression and maturation of STZ-induced cataract in rats. Cumin prevented

loss of chaperone activity in diabetic rats and also attenuated the structural changes of α-crystallin in lens, which is a long-lived protein and is susceptible to several post-translational modifications in certain diabetic conditions.[113] Eight-week sub-acute administration of cumin to STZ-diabetic rats reduced hyperglycemia and glucosuria accompanied by an improvement in body weight, blood urea and reduced excretion of urea and creatinine.[114] Oral administration of cumin also showed hypoglycemic effect in normal rabbit, resulting in significant decrease in the area under the glucose tolerance curve.[110] Caraway oil exhibited anti-hyperglycemic activity in alloxan-induced diabetic rats and increased the body weight.[115] A similar effect was recorded in STZ diabetic rats, while no changes were observed in basal plasma insulin concentrations, indicating that the underlying mechanism of this pharmacological activity seems to be independent of insulin secretion.[116] The biologically active constituent of cumin seed oil was characterized as cuminaldehyde which inhibited aldose reductase and alpha-glucosidase isolated from rat.[29] In hyperglycemia associated with diabetes, the use of aldose reductase inhibitors has shown efficacy in attenuating diabetic complications.

Hyperlipidemia is an associated complication of diabetes mellitus. Oral administration of cumin to alloxan diabetic rats reduced body weight, plasma and tissue cholesterol, phospholipids, free fatty acids and triglycerides. Histological observations demonstrated significant decrease in fatty changes and inflammatory cell infiltrates in diabetic rat pancreas.[111] Cumin suppressed alcohol and thermally oxidized oil induced hyperlipidemia. It decreased aspartate transaminase (AST), alkaline phosphatase (ALP) and γ-glutamyl transferase (GGT) activities and decreased the tissue (liver and kidney) levels of cholesterol, triglycerides and phospholipids and prevented the changes in the composition of fatty acids in the plasma of rats administered with alcohol and/or thermally oxidized oil. The activity of phospholipase A and C decreased significantly.[102,117] Hypocholesterolemic effect of methanolic extract of *cumin is also documented in ovariectomized rat in relation to its anti-osteoporotic effect*.[118] Aqueous extract of caraway showed potent lipid lowering activity (hypotriglyceridemic and hypocholesterolemic) in both normal and STZ-diabetic rats after single and repeated oral administration.[119] Cumin added to a hypercholesterolemic diet decreased serum and liver cholesterol in rats.[120]

### Diuretic

The traditional use of caraway as a diuretic was confirmed in an experimental study in which peroral treatment of an aqueous extract of caraway (in acute and sub-chronic mode) was shown to increase the urine output during and after 24 hours in rat. The urinary levels of sodium and potassium were found to be increased, while in plasma these were not affected. Carum extract did not produce any renal toxicity or any other adverse effects during the study period.[6]

### Immunomodulatory

In a recent study, oral treatment with cumin showed immunomodulatory properties in normal and immune-suppressed animals via modulation of T lymphocytes′ expression in a dose-dependent manner. It stimulated the T cells′ (CD4 and CD8) and Th1 cytokines′ expression in normal and cyclosporine-A induced immune-suppressed mice. In restraint stress-induced immune-suppressed animals, the active compound of cumin countered the depleted T lymphocytes, decreased the elevated corticosterone levels and size of adrenal glands and increased the weight of thymus and spleen.[121]

### CNS

Administration of cumin oil suppressed the development and expression of morphine tolerance (as measured by tail-flick method). The morphine dependence was also reversed in a dose-dependent manner as evaluated by decreased conditioning scores (the acquisition and expression of morphine-induced

conditioned place preference) in mice.[122,123] Anti-epileptic activity of cumin oil is documented. It decreased the frequency of spontaneous activity induced by pentylenetetrazol (PTZ). This protection was measured in a time- and concentration-dependent manner as increased duration, decreased amplitude of hyperpolarization potential, the peak and firing rate of action potential and excitability of nerve cells.[124] Cumin oil was found to attenuate seizures induced by maximal electroshock and PTZ in mice.[125] Cumin oil has also been found to possess significant analgesic action in a chemical model (formalin test) of nociception in rat.[126] Cuminaldehyde [Figure 2b] was found to be a tyrosinase inhibitor and prevented the oxidation of l-3.5-dihydroxyphenyklalanine (l-DOPA).[127] The adaptogenic and antistress activity of an aqueous extract of caraway is documented in normal and stress induced rats (forced swim stress test) which was related to its antioxidant property.[128]

### Estrogenic/anti-osteoporotic

Cumin and caraway seeds are reported to be estrogenic.[129] Potential effects of caraway on hormone and reproductive parameters of female ovariectomized rats are demonstrated due possibly to the presence of estrogenic isoflavonoids, luteolin and apigenin. An aqueous and an ethanolic extract of caraway seeds produced significant antifertility effect via modulation of follicle stimulating hormone (FSH) and leutinizing hormone (LH) levels, while the estrogen levels were increased. This was accompanied by an increase in the weight of ovary, uterus and also body weight.[130] Caraway oil was effective in inhibiting tonic and phasic rhythmic contractions of isolated uterine preparations.[35] The presence of phytoestrogens in cumin has been shown and also related to its anti-osteoporotic effects. In the animals receiving a methanolic extract of cumin, a significant reduction in urinary calcium excretion and augmentation of calcium content and mechanical strength of bones was found. Animals showed greater bone and ash densities and improved microarchitecture, with no adverse effects like body weight gain and weight of atrophic uterus.[131]

### Gastrointestinal

In human trial studies, some herbal preparations consisting predominantly caraway have shown efficacy in relieving dyspeptic symptoms.[132] The antispasmodic effect of an alcoholic extract of caraway has shown inhibitory effects on smooth muscle contractions induced by the spasmogens, acetylcholine and histamine.[133,134] This response has been evaluated to explain the beneficial effect of caraway in relieving gastrointestinal symptoms associated with dyspepsia. In a study done on 12 intestinal bacteria, caraway oil displayed high degree of selectivity, inhibiting the growth of potential pathogens at concentrations that had no effect on the beneficial bacteria examined. This effect was related to the efficacy and usefulness of caraway oil in traditional medicine for treating dysbiosis which is associated with a number of gastrointestinal and systemic disorders.[135] Solvent derived extracts of caraway seed showed antibacterial activity against gram-negative bacterium *Helicobacter pylori* and its clinical isolates. *H. pylori* is recognized as the primary etiological factor associated with the development of gastritis and peptic ulcer diseases along with chronic gastritis, gastric carcinoma and primary gastric B-cell lymphoma.[136–138] Extracts from caraway produced dose-dependent antiulcerogenic effect against indomethacin-induced gastric ulcers, accompanied by reduction in acid and leukotrienes′ output, and increased mucin secretion and prostaglandin E2 release. The antiulcerogenic activity was also confirmed histologically and was attributed to its flavonoid content and free radical scavenging properties.[139] Perfusion of an aqueous extract of cumin via the stomach of pentobarbitone-anesthetized rats under the aspirin-induced gastric mucosal injury showed an increased acid secretion by a cholinergic mechanism.[140] Aqueous and solvent derived extracts of cumin increased amylase, protease, lipase and phytase activities.[58]

### Other biodynamic actions

Aqueous extract of cumin was found to be antitussive and produced relaxant effect on guinea pig isolated tracheal chain via its stimulatory effect on beta-adrenoreceptors and/or histamine H1 receptors.[141,142] An ethereal extract of cumin showed antiaggregatory activity and inhibited eicosanoid synthesis. It inhibited arachidonic acid (AA)-induced platelet aggregation and also thromboxane B2 production from exogenous AA; a simultaneous increase in the formation of lipoxygenase-derived products was also observed. Cumin extract also inhibited collagen and adrenaline-induced aggregation.[143,144] Acute and subchronic administration of cumin oil decreased WBC count and increased the hemoglobin concentration, hematocrit, and platelet counts. LDL/HDL ratio was reduced to half.[61] Caraway oil has been evaluated for its possible hepatoprotective effect. In mice treated with carbontetrachloride, a hepatotoxin, caraway oil maintained the activities of xenobiotics detoxifying enzymes, glutathione S-transferase (GST) and glutathione peroxidase (GSH-Px) and the levels of reduced glutathione (GSH), in preventing lipid peroxidation which is the main consequence of the action of this hepatotoxin.[62] Anaqueous extract of cumin seeds showed protective action against gentamycin-induced nephrotoxicity. It decreased the gentamycin-induced elevated levels of serum urea, creatinine, lipid peroxidation and enhanced the clearance of the drug.[145]

### Drug bioavailability enhancing activity

In recent studies carried out in the author's laboratory,[146,147] a significant pharmacokinetic interaction of some herbal products from cumin and caraway with anti-tubercular drugs has been revealed. An aqueous extract derived from cumin seeds produced a significant enhancement of rifampicin levels in rat plasma. This bioenhancer activity was found to be due to a novel flavonoid glycoside isolated from cumin. This was identified as 3′,5-dihydroxyflavone 7-O-β-d-galacturonide-4′-O-β-d-glucopyranoside [Figure 3], which enhanced the peak concentration ($C_{max}$ ) and area under the curve (AUC) of rifampicin by 35 and 53%, respectively, when co-dosed with this molecule. On the other hand, a chemically standardized butanolic fraction of caraway seed enhanced the plasma levels of three anti-TB drugs: rifampicin (RIF), pyrazinamide (PZA), and isoniazid (INH), when co-dosed in combination in rat. In the presence of the herbal fraction of caraway, $C_{max}$ and AUC of RIF were enhanced by 63% and 53% respectively; for PZA, this increase was 57 and 35%, respectively; and for INH, this increase was 40 and 25%, respectively. The altered bioavailability profile of anti-TB drugs could be attributed to a permeation enhancing effect of cumin and caraway.[146,147]

## CONCLUSION

Although advances in chemical and pharmacological evaluation of cumin and caraway have occurred in the recent past, they have always remained a hallmark of traditional drugs in diverse cultures. The chemical constituents of carum and caraway seem to be a bewildering array of compounds and to ascribe certain biological activity to a particular compound has remained a formidable task. Although individually some identified compounds have been associated with a bioactivity, it cannot be said about any particular mixture of compounds. It seems reasonable to assume that the “synergy” between and within a particular class of compound might be responsible for the remarkable bioactivity profile of this herb. Nonetheless, the pharmacological activities found in cumin and caraway overwhelmingly substantiate their preferred use in traditional medicaments.

In recent times, considerable information has also become available with respect to herb–drug interactions. Numerous evidences exist for many documented medicinal herbs, which suggest that such interactions could produce potential effects *in vivo*.[148] Prominent among the many effects of these herb-drug interactions is the drug bioavailability. In this context, natural products which could facilitate the bioavailability of poorly bioavailable drugs offer great promise. Besides understanding of the natural

products as an alternative to conventional treatment, cumin and caraway seem well positioned as a source of new entities to boost the bioavailability and bioefficacy of the existing medicines by virtue of their newly revealed bioenhancer action profile and need further exploration.

## Footnotes

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## REFERENCES

1. Joshi SG. 1st ed. Delhi: Oxford and IBH Publishing Co. Pvt. Ltd; 2000. Medicinal plants: Family Apiaceae.

2. Mhaskar KS, Blatter E, Caius JF, editors. Vol. 5. New Delhi: Satguru Publications; 2000. In Kiritikar and Basu's Illustrated Indian Medicinal Plants.

3. Perry LM. Massachusetts and London: The MIT Press; 1980. Medicinal Plants of East and Southeast Asia.

4. Sivarajan VV, Balachandran I. New Delhi: Oxford and IBH Publication; 1994. Ayurvedic Drugs and their Plant Sources.

5. Zargary A. 5th ed. Tehran: Tehran University Publications; 2001. Medicinal Plants.

6. Lahlou S, Tahraoui A, Israili Z, Lyoussi B. Diuretic activity of the aqueous extracts of *Carum carvi* and *Tanacetum vulgare* in normal rats. J Ethnopharmacol. 2007;110:458–63. [PubMed: 17113735]

7. Tahraoui A, El-Hilay J, Israili ZH, Lyoussi B. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia province) J Ethnopharmacol. 2007;110:105–17. [PubMed: 17052873]

8. Leporatti ML, Ghedira K. Comparative analysis of medicinal plants used in traditional medicine in Italy and Tunisia. J Ethnobiol Ethnomed. 2009;5:31–9. [PMCID: PMC2773757] [PubMed: 19857257]

9. Al–Yahya M, Collpharm A. Phytochemical studies of plant used in traditional medicine in Saudi Arabia. Fitoterapia. 1986;57:179–82.

10. Sadowska A, Obidoska G. Caraway. In: Nemeth E, editor. The Genus Carum. USA: CRC Press; 2004.

11. Agarwal SG, Thappa RK, Dhar KL, Atal CK. Essential oils of the seeds of *Bunium bulbocastanum, Carum gracile* Lindle and *Cuminum cyminum*. Ind Perfum. 1979;22:164–5.

12. Agrawal S. Volatile oil constituents and wilt resistance in cumin (*Cuminum cyminum* L.) Curr Sci Ind. 1996;71:177–8.

13. Bettaieb I, Bourgou S, Wannes WA, Hamrouni I, Limam F, Marzouk B. Essential oils, phenolics and antioxidant activities of different parts of cumin (*Cuminum cyminum* L.) J Agric Food Chem. 2010;58:10410–8. [PubMed: 20809647]

14. Borges P, Pino J. The isolation of volatile oil from cumin seeds by steam distillation. Nahrung. 1993;37:123–6.

15. Bouwmeester HJ, Gershenzon J, Konings MC, Croteau R. Biosynthesis of the monoterpenes limonene and carvone in the fruit of caraway: I: Demonstration of enzyme activities and their changes with development. Plant Physiol. 1998;117:901–12. [PMCID: PMC34944] [PubMed: 9662532]

16. De Martino L, De Feo V, Fratianni F, Nazzaro F. Chemistry, antioxidant, antibacterial and antifungal activities of volatile oils and their components. Nat Prod Commu. 2009;4:1741–50.

17. Eikani MH, Goodarznia I, Mirza M. Supercritical carbon dioxide extraction of cumin seeds (*Cuminum cyminum* L.) Flav Frag J. 1999;14:29–31.

18. El-Ghorab AH, Nauman M, Anjum FM, Hussain S, Nadeem M. A comparative study on chemical composition and antioxidant activity of ginger (*Zingiber officinale*) and cumin (*Cuminum cyminum*) J Agric Food Chem. 2010;58:8231–3. [PubMed: 20590154]

19. El-Sawi SA, Mohamed MA. Cumin herb as a new source of essential oils and its response to foliar spray with some micro-nutrients. Food Chem. 2002;77:75–80.

20. Gachkar L, Yadegari D, Rezaei MB, Taghizadeh M, Astaneh SA, Rasooli I. Chemical and biological characteristics of *Cuminum cyminum* and *Rosemarinus officinalis* essential oils. Food Chem. 2007;102:898–904.

21. Hajlaoui H, Mighri H, Noumi E, Snoussi M, Trabelsi N, Ksouri R, et al. Chemical composition and biological activities of Tunisian *Cuminum cyminum* L.essential oil: A high effectiveness against *Vibrio* spp. strains. Food Chem Toxicol. 2010;48:2186–92. [PubMed: 20488223]

22. Hashemi P, Shamizadeh M, Badiei A, Ghaisvand AR, Azizi K. Study of the essential oil composition of cumin seeds by an amino ethyl fundtionalized nanoporous SPME fibre. Chromatographia. 2009;70:1147–51.

23. Iacobellis NS, Lo Cantore P, Capasso F, Senatore F. Antibacterial activity of *Cuminum cyminum* L. and *Carum carvi* L. essential oils. J Agric Food Chem. 2005;53:57–61. [PubMed: 15631509]

24. Ishikawa T, Takayanagi T, Kitazima J. Water-soluble constituents of cumin: Monoterpenoid glucosides. Chem Pharm Bull. 2002;50:1471–8. [PubMed: 12419912]

25. Jalali-Heravi M, Zekavat B, Sereshti H. Use of gas chromatography-mass spectrometry combined with resolution methods to characterize the essential oil components of Iranian cumin and caraway. J Chromatogr A. 2007;1143:215–26. [PubMed: 17258753]

26. Jirovetz L, Buchbauer G, Stoyanova AS, Georgiev EV, Damianova ST. Composition, quality control and antimicrobial activity of the essential oil of cumin (*Cuminum cyminum* L.) seeds from Bulgaria that had been stored upto 36 years. Int J Food Sci Technol. 2005;40:305–10.

27. Kallio H, Kerrola K, Alhonmaki P. Carvone and limonene in caraway fruits (*Carum carvi* L.) analyzed by supercritical carbon dioxide extraction-gas chromatography. J Agric Food Chem. 1994;42:2478–85.

28. Kumar P, Baslas RK. Chemical examination of essential oil of the seeds of *Cuminum cyminum*. Ind Perfum. 1978;22:164–5.

29. Lee HS. Cuminaldehyde: Aldose Reductase and alpha-glucosidase inhibitor derived from *Cuminum cyminum* L. seeds. J Agric Food Chem. 2005;53:2446–53. [PubMed: 15796577]

30. Li R, Jiang ZY. Chemical composition of the essential oil of *Cuminum cyminum* L. from China. Flav Frag J. 2004;19:311–4.

31. Mehdi RA, Masoomch SG, Mohammad BR, Kamkar J, Soheil A, Reza S, et al. Chemical composition and antiaflatoxicogenic activity of *Carum carvi* L., *Thymus vulgaris* and *Citrus aurantifolia* essential oils. Food Contr. 2009;20:1018–24.

32. Oroojalian F, Kasra-Kermanshahi R, Azizi M, Bessami MR. Phytochemical composition of the essential oils from three Apiaceae species and their antibacterial effects on food-borne pathogens. Food Chem. 2010;120:765–70.

33. Richter J, Schellenberg I. Comparison of different extraction methods for the determination of essential oils and related compounds from aromatic plants and optimization of solid-phase microextraction/ gas chromatography. Anal Bioanal Chem. 2007;387:2207–17. [PubMed: 17221240]

34. Salveson A, Svendsen AB. Gas liquid chromatographic separation and identification of the constituents of caraway seed oil: I; The monoterpene hydrocarbons. Planta Med. 1976;8:93–6. [PubMed: 959400]

35. Sadraei H, Ghannadi A, Takei-Bavani Effects of *Zaratia multiflora* and *Carum carvi* essential oils and hydroalcoholic extracts of *Passiflora incarnate, Berberis integerrima* and *Crocus sativus* on rat isolated uterus contractions. Int J Aromather. 2003;13:1210–7.

36. Sedlakova J, Kocourkova B, Kuban V. Determination of essential oil content and composition in caraway (*Carum carvi L.*) Czech J Food Sci. 2001;19:31–6.

37. Sedlakova J, Kocourkova B, Lojkova L, Kuban V. Determination of essential oil content in caraway (*Carum carvi L.*) species by means of supercritical fluid extraction. Plant Soil Environ. 2001;49:277–82.

38. Simic A, Rancic A, Sokovic MD, Ristic M, Grujic-Javanovic A, Vukojevic J, et al. Essential oil composition fo Cymbopogon winterianus and Carum carvi and their antimicrobial activities. Pharm Biol. 2008;46:437–41.

39. Topal U, Sasaki M, Goto M, Otles S. Chemical compositions and antioxidant properties of essential oils from nine species of Turkish plants obtained by supercritical carbon dioxide extraction and steam distillation. Int J Food Sci Nutr. 2008;59:619–34. [PubMed: 19382349]

40. Zheng GQ, Kenney PM, Lamm LK. Anethofuran, carvone, and limonene: Potential cancer chemopreventive agents from dill weed oil and caraway oil. Planta Med. 1992;58:338–41. [PubMed: 1438594]

41. Laribi B, Kouki K, Mougou A, Marzouk B. Fatty acid and essential oil composition of three Tunisian caraway (*Carum carvi* L.) seed ecotypes. J Sci Food Agric. 2010;90:391–6. [PubMed: 20355058]

42. Ngo-Duy C, Destaillats F, Keskitalo M, Arul J, Angers P. Triacylglerols of Apiaceaae seed oils: composition and regiodistribution of fatty acids. Eur J Lipid Sci Technol. 2009;111:164–9.

43. Reiter B, Lechner M, Lorbeer E. The fatty acid profiles-including petroselinic and cis-vaccenic acid-of different Umbelliferae seed oils. Fett/Lipid. 1998;100:498–502.

44. Seidler-Lozykowska K, Baranska M, Baranski R, Krol D. Raman analysis of caraway (*Carum carvi* L.) single fruits. Evaluation of essential oil content and its composition. J Agric Food Chem. 2010;58:5271–5. [PubMed: 20402506]

45. Yetim H, Sagdic O, Ozturk I. Fatty acid composition of cold press oils of seven edible plant seeds grown in Turkey. Chem Nat Compd. 2008;44:634–6.

46. El-Negoumy SI, Mansour RMA. Flavone glycosides of *Cuminum cyminum* seeds. Grasa Y Aceites. 1989;40:87–9.

47. Khafagy SM, Sarg TM, Abdel Salam NA, Gabr O. Isolation of two flavone glycosides from the fruits of *Cuminum cyminum* L. grown in Egypt. Pharmazie. 1978;33:296–7. [PubMed: 674343]

48. Kitazima J, Ishikawa T, Fujimatu E, Kondho K, Takayanagi T. Glycosides of 2-C-methyl-D-erythritol from the fruits of anise, coriander and cumin. Phytochemistry. 2003;62:115–20. [PubMed: 12475627]

49. Kunzemann J, Herrmann K. Isolation and identification of flavon(ol)-glycosides in caraway (*Carum carvi* L.), fennel (*Foeniculum vulgare* Mill.), anise (*Pimpinella anisum* L.) and coriander (Coriandrum sativum L), and of flavon-c-glycosides in anise I Phenolics of spices. A. Lebensm Unters Forsch. 1977;164:194–200.

50. Matsumara T, Ishikawa T, Kitazima J. Water-soluble constituents of caraway: aromatic compound, glucoside and glucides. Phytochemistry. 2002a;61:455–9.

51. Matsumara T, Ishikawa T, Kitazima J. Water-soluble constituents of caraway: Carvone derivatives and their glucosides. Chem Pharm Bull. 2002b;50:66–72.

52. Takayanagi T, Ishikawa T, Kitazima J. Sesquiterpene lactone glucosides and alkyl glycosides from the fruit of cumin. Phytochemistry. 2003;63:479–84. [PubMed: 12770603]

53. Najda A, Dyduch J, Brzozowski N. Flavonoid content and antioxidant activity of caraway roots (*Carum carvi* L.) Veg Crops Res Bull. 2008;68:127–33.

54. Nakano Y, Matsunaga H, Saita T, Mori M, Katano M, Okabe H. Antiproliferative constituents in Umbelliferae plants II: Screening for polyacetylenes in some Umbelliferae plants, and isolation of panaxynol and falcarindiol from the root of *Heracleum moellendorffii*. Biol Pharm Bull. 1998;21:257–61. [PubMed: 9556156]

55. Zaman U, Abbasi A. Isolation, purification and characterization of a nonspecific lipid transfer protein from *Cuminum cyminum*. Phytochemistry. 2009;70:979–87. [PubMed: 19473681]

56. Al-Bataina BA, Maslat AO, Al-Kofahil MM. Element analysis and biological studies on ten oriental spices using XRF and Ames test. J Trace Elem Med Biol. 2003;17:85–90. [PubMed: 14531636]

57. Maiga A, Diallo D, Bye R, Paulsen BS. Determination of some toxic and essential metal ions in medicinal and edible plants from Mali. J Agric Food Chem. 2005;53:2316–21. [PubMed: 15769174]

58. Milan KSM, Dholakia H, Tiku PK, Vishveshwaraiah P. Enhancement of digestive enzymatic activity by cumin (*Cuminum cymonum* L.) and role of spent cumin as a bionutrient. Food Chem. 2008;110:678–83.

59. Toghrol F, Daneshpejouh H. Estimation of free amino acids, protein and amino acid compositions of cumin seed (*Cuminum cyminum*) of Iran. J Trop Pediatr Environ Child Health. 1974;20:109–11. [PubMed: 4497570]

60. Uma Pradeep K, Geervani P, Eggum BO. Common Indian spices: Nutrient composition, consumption and contribution to dietary value. Plant Foods Hum Nutr. 1993;44:137–48. [PubMed: 8397396]

61. Allaghadri T, Rasooli I, Owlia P, Nadooshan MJ, Ghanfari T, Taghizadeh M, et al. Antimicrobial property, antioxidant capacity, and cytotoxicity of essential oil from cumin produced in Iran. J Food Sci. 2010;75:H54–61. [PubMed: 20492235]

62. Bukhari SB, Iqbal S, Bhangar MI. Antioxidant potential of commercially available cumin (*Cuminum cyminum* Linn.) Int J Food Sci Nutr. 2009;60:240–7. [PubMed: 18720171]

63. Lado C, Then M, Varga I, Szoke E, Azentminalyi K. Antioxidant property of volatile oils determined by ferric reducing ability. Z Naturforsch. 2004;59c:354–8.

64. Polovka M, Suhaj M. Detection of caraway and bay leaves irradiation based on their extracts

antioxidant properties evaluation. Food Chem. 2010;119:391–401.

65. Ramadan MF, Moersel JT. Screening of the antiradical action of vegetable oils. J Food Comp Anal. 2006;19:838–42.

66. Reddy A, Lokesh BR. Studies on spice principles as antioxidant in the inhibition of lipid peroxidation or rat liver microsomes. Mol Cell Biochem. 1992;111:117–24. [PubMed: 1588934]

67. Samojlik I, Lakic N, Mimica-Dukic N, Dakovic-Svajcer K, Bozin B. Antioxidant and hepatoprotective potential of essential oils of coriander (*Coriandrum sativum* L.) and caraway (*Carum carvi* L.) (Apiaceae) J Agric Food Chem. 2010;58:8848–53. [PubMed: 20608729]

68. Satyanarayana S, Sushruta K, Sarma GS, Srinivas N, Subba Raju GV. Antioxidant activity of the aqueous extracts of spicy food additives-evaluation and comparison with ascorbic acid in *in-vitro* systems. J Herb Pharmacother. 2004;4:1–10. [PubMed: 15364640]

69. Singh G, Marimuthu P, Murali HS, Bawa AS. Antiooxidative and antibacterial potentials of essential oils and extracts isolated from various spice materials. J Food Saf. 2005;25:130–45.

70. Thippeswamy NB, Naidu A. Antioxidant potency of cumin varieties - cumin, black cumin and bitter cumin - on antioxidant systems. Eur Food Res Technol. 2005;220:472–6.

71. Ruberto G, Baratta MT. Antioxidant activity of selected essential oil components in two lipid model systems. Food Chem. 2000;69:167–74.

72. Rodov V, Vinokur Y, Gogia N, Chkhikvishvili I. Hydrophilic and lipophilic antioxidant capacities of Georgian spices for meat and their possible health implications. Georgian Med News. 2010;179:61–6. [PubMed: 20234067]

73. Agnihotri S, Vaidya AD. A novel approach to study antibacterial properties of volatile components of selected Indian medicinal herbs. Indian J Exp Biol. 1996;34:712–5. [PubMed: 8979514]

74. Deb Roy S, Thakur S, Negi A, Kumari M, Sutar N, Jana GK. In vitro antibiotic activity of volatile oils of *Carum carvi* and *Coriandrum sativum*. Int J Chem Analyt Sci. 2010;1:149–50.

75. Irkin R, Korukluoglu M. Growth inhibition of pathogenic bacteria and some yeasts by selected essential oils and survival of *L. monocytogenes* and *C. albicans* in apple-carrot juice. 2009;6:387–94.

76. Shetty RS, Singhal RS, Kulkarni PR. Antimicrobial properties of cumin. World J Microbiol Biotechnol. 1994;10:232–3.

77. Singh G, Kapoor IP, Pandey SK, Singh UK, Singh RK. Studies on essential oils: Part 10; Antibacterial activity of volatile oils of some spices. Phytother Res. 2002;16:680–2. [PubMed: 12410554]

78. Youssef BM, Hammad AA. Comparative antibacterial effect of garlic and cumin essential oils. Egypt J Microbiol. 2010;29:131–7.

79. Vicuda-Martos M, Ruiz-Navajas Y, Fernandez-Lopez J, Perez-Alvarez JA. Antibacterial activity of different essential oils obtained from spices widely used in Mediterranean diet. Int J Food Sci Technol. 2008;43:526–31.

80. Derakhshan S, Sattari M, Bigdeli M. Effect of sub-inhibitory concentrations of cumin (*Cuminum cyminum* L.) seed essential oil and alcoholic extract on the morphology, capsule expression and urease activity of Klebsiella pneumoniae. Int J Antimicrob Agents. 2008;32:432–6. [PubMed: 18715764]

81. Derakhshan S, Sattari M, Bigdeli M. Effect of cumin (*Cuminum cyminum* L.) seed essential oil on

biofilm formation and plasmid integrity by *Klebsiella pneumoniae*. Pharmacog Mag. 2010;6:57–61. [PMCID: PMC2881652]

82. Shayegh S, Rasooli I, Taghizadeh M, Astaneh SD. Phytotherapeutic inhibition of supragingival dental plaque. Nat Prod Res. 2008;22:428–39. [PubMed: 18404563]

83. Dorman HJD, Deans SG. Antimicrobial agents from plants: Antibacterial activity of plant volatile oils. J Appl Microbiol. 2000;88:308–16. [PubMed: 10736000]

84. Farag RS, Daw ZY, Hewedi FM, El Baroty GSA. Antimicrobial activity of some Egyptian spice essential oils. J Food Prot. 1989;52:665–7.

85. Helander IM, Alakomi HL, Latva-Kala K, Mattila-Sandholm T, Pol I, Smid EJ, et al. Characterization of the action of selected essential oil components on gram-negative bacteria. J Agric Food Chem. 1998;46:3590–5.

86. Kim J, Marshall MR, Wei C. Antibacterial activity of some essential oils components against the foodborne pathogens. J Agric Food Chem. 1995;43:2839–45.

87. Burt S. Essential oils: Their antibacterial properties and potential applications in foods: A review. Int J Food Microbiol. 2004;94:223–53. [PubMed: 15246235]

88. Boyraz N, Ozcan M. Antifungal effect of some spice hydrosols. Fitoterapia. 2005;76:661–5. [PubMed: 16243447]

89. Farag RS, Daw ZY, Abo-Raya SH. Influence of some spice essential oils on *Aspergillus parasiticus* growth and production of aflatoxins in a synthetic medium. J Food Sci. 1989a;54:74–6.

90. Farag RS, Daw ZY, Hewedi FM, El Baroty GS. Antimicrobial activity of some Egyptian spice essential oils. J Food Prot. 1989b;52:665–7.

91. Hammad AAI, Youssef BM. Growth inhibition of some pharmacological molds by garlic and cumin essential oils. Egypt J Microbiol. 1995;29:115–20.

92. Razzaghi-Abyaneh M, Shams-Ghahfarokhi M, Rezaee MB, Jimand K, Alinezahad S, Saberi R. Chemical composition and antiaflatoxigenic activity of *Carum carvi L, Thymus vulgaris* and *Citrus aurantifolia* essential oils. Food Contr. 2009;20:1018–24.

93. Romagnoli C, Andreotti E, Maietti S, Mahendra R, Mares D. Antifungal activity of essential oil from fruits of Indian *Cuminum cyminum*. Pharm Biol. 2010;48:834–48. [PubMed: 20645785]

94. Skrinjar MM, Mandi AI, Misan AC, Sakac MB, Saric LC, Zec MM. Effect of mint (*Mentha piperita* L.) and Caraway (*Carum carvi* L.) on the growth of some toxicogenic Aspergillus species and aflatoxin B production. Proc Nat Sci Matica Srpska Novi Sad. 2009;116:131–9.

95. Nalini N, Sabitha K, Vishwanathan P, Menon VP. Influence of spices on the bacterial (enzyme) activity in experimental colon cancer. J Ethnopharmacol. 1998;62:15–24. [PubMed: 9720607]

96. Nalini N, Manju V, Menon VP. Effect of spices on lipid metabolism in 1,2-dimethylhydrazine-induced rat colon carcinogenesis. J Med Food. 2006;9:237–45. [PubMed: 16822210]

97. Kamaleeshwari M, Deeptha K, Sengottuvelan M, Nalini N. Effect of dietary caraway on aberrant crypt foci development, fecal steroids, and intestinal alkaline phosphatase activities in 1,2-dimethylhydrazine-induced colon carcinogenesis. Toxicol Appl Pharmacol. 2006a;214:290–6.

98. Deeptha K, Kamaleeshwari M, Sengottuvelan M, Nalini N. Dose dependent inhibitory effect of dietary

caraway on 1, 2-dimethylhydrazine induced colonic aberrant crypt foci and bacterial enzyme activity in rats. Invest. New Drugs. 2006;24:479–88.

99. Aruna K, Sivaramakrishnan VM. Anticarcinogenic effects of some Indian plant products. Food Chem Toxicol. 1992;30:953–6. [PubMed: 1473788]

100. Gagandeep S, Dhanalakshmi S, Mendiz E, Rao AR, Kale RK. Chemopreventive effects of *Cuminum cyminum* in chemically induced forestomach and uterine cervix tumors in murine model systems. Nutr Cancer. 2003;47:171–80. [PubMed: 15087270]

101. aderi-Kalali B, Allameh A, Rasaee MJ, Bach HJ, Behechti A, Doods K, et al. Suppressive effects of caraway (*Carum carvi*) extracts on 2, 3, 7, 8-tetrachloro- dibenzo-p-dioxin-dependent gene expression of cytochrome P450 1A1 in the rat H4IIE cells. Toxicol In vitro. 2005;19:373–7. [PubMed: 15713544]

102. Aruna K, Rukkumani R, Varma PS, Menon VP. Therapeutic role of *Cuminum cyminum* on ethanol and thermally oxidized sunflower oil induced toxicity. Phytother Res. 2005;19:416–21. [PubMed: 16106395]

103. Kamaleeswari M, Nalini N. Dose-response efficacy of caraway on tissue lipid peroxidation and antioxidant profile in rat colon carcinogenesis. J Pharm Pharmacol. 2006b;58:1121–30. [PubMed: 16872560]

104. Wattenberg LW. Inhibition of carcinogenesis by naturally-occurring and synthetic compounds. Basic Life Sci. 1990;52:155–66. [PubMed: 2183767]

105. Wattenberg LW, Sparnins VL, Barany G. Inhibition of N-nitrosodiethylamine carcinogenesis in mice by naturally occurring organosulfur compounds and monoterpenes. Cancer Res. 1990;49:2689–92. [PubMed: 2713853]

106. Bogucka-Kocka A, Smolarz HD, Kocki J. Apoptotic activities of ethanol extracts from some Apiaceae on human leukaemia cell lines. Fitoterapia. 2008;79:487–97. [PubMed: 18672039]

107. Higashimoto M, Purintrapiban J, Kataoka K, Kinouchi T, Vinitketkumnuen U, Akimoto S, et al. Mutagenicity and antimutagenicity of extracts of three spices and a medicinal plant in Thailand. Mut Res. 1993;303:135–42. [PubMed: 7694130]

108. Mazaki M, Kataoka K, Kinouchi T, Vinitketkumnuen U, Yamada M, Nohmi T, et al. Inhibitory effects of caraway (*Carum carvi L.*) and its component on N-methyl-N'-nitro-N-nitrosoguanidine-induced mutagenicity. J Med Invest. 2006;53:123–33. [PubMed: 16538005]

109. Srinivasan K. Plant foods in the management of diabetes mellitus: Spices as beneficial antidiabetic food adjuncts. Int J Food Sci Nutr. 2005;56:399–414. [PubMed: 16361181]

110. Roman-Ramos R, Flores-Saenz JL, Alarcon-Aguilar FJ. Anti-hyperglycemic effect of some edible plants. J Ethnopharmacol. 1995;48:25–32. [PubMed: 8569244]

111. Dhandapani S, Subramanian VR, Rajagopal S, Namasivayam N. Hypolipidemic effect of *Cuminum cyminum* L.on alloxan-induced diabetic rats. Pharmacol Res. 2002;46:251–5. [PubMed: 12220968]

112. Jagtap AG, Patil PB. Antihyperglycemic activity and inhibition of advanced glycation end product formation by *Cuminum cyminum* in streptozotocin induced diabetic rats. Food Chem Toxicol. 2010;48:2030–6. [PubMed: 20451573]

113. Kumar PA, Reddy PY, Srinivas PN, Reddy GB. Delay of diabetic cataract in rats by the antiglycating potential of cumin through modulation of α-crystallin chaperone activity. J Nutr Biochem. 2009;20:553–

62. [PubMed: 18789666]

114. Willatgamuva SA, Platel K, Sarawathi G, Srinivasan K. Antidiabetic influence of dietary cumin seeds (*Cuminum cyminum*) in streptozotocin induced diabetic rats. Nutr Res. 1998;18:131–42.

115. Ene AC, Nwankwo EA, Samdi LM. Alloxan-induced diabetes in rats and the effects of black caraway (*Carum carvi* L.) oil on their body weight. Res J Med Med Sci. 2007;2:48–52.

116. Eddouks M, Lemhadri A, Michel JB. Caraway and caper: potential anti-hyperglycaemic plants in diabetic rats. J Ethnopharmacol. 2004;94:143–8. [PubMed: 15261975]

117. Kode A, Rajagopalan R, Penumathsa SV, Menon VP. Effect of ethanol and thermally oxidized sunflower oil ingestion on phospholipid fatty acid composition of rat liver: Protective role of *Cuminum cyminum* L. Ann Nutr Metab. 2005;49:300–3. [PubMed: 16088094]

118. Shirke SS, Jagtap AG. Effects of methanolic extract of *Cuminum cyminum* on total serum cholesterol in ovariectomized rats. Indian J Pharmacol. 2009;41:92–3. [PMCID: PMC2841243] [PubMed: 20336228]

119. Lemhadri A, Hajji L, Michel JB, Eddouks M. Cholesterol and triglycerides lowering activities of caraway fruits in normal and streptozotocin diabetic rats. J Ethnopharmacol. 2006;106:321–6. [PubMed: 16567073]

120. Sambaiah K, Srinivasan K. Effect of cumin, cinnamon, ginger, mustard and tamarind in induced hypercholesterolemic rats. Nahrung. 1991;35:47–51. [PubMed: 1865890]

121. Chauhan PS, Satti NK, Suri KA, Amina M, Bani S. Stimulatory effects of *Cuminum cyminum* and flavonoid glycoside on cyclosporine-A and restraint stress induced immune-suppression in swiss albino mice. Chem Biol Interac. 2010;185:66–72.

122. Haghparast A, Shams J, Khatibi A, Alizaseh AM, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* Linn. (Apiaceae) on acquisition and expression of morphine tolerance and dependence in mice. Neurosci Lett. 2008;440:134–9. [PubMed: 18550281]

123. Khatibi A, Hagrarast A, Shams J, Dianati E, Komaki A, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* L.on the acquisition and expression of morphine-induced conditioned place preference in mice. Neurosci Lett. 2008;448:94–8. [PubMed: 18950682]

124. Janahmadi M, Niazi F, Danyali S, Kamalinejad M. Effects of the fruit essential oil of *Cuminum cyminum* Linn. (Apiaceae) on pentylenetetrazol-induced epileptiform activity in F1 neurones of *Helix aspersa*. J Ethnopharmacol. 2006;104:278–82. [PubMed: 16226415]

125. Sayyah M, Mahboubi A, Kamalinejad M. Anti-convulsant effect of the fruit essential oil of *Cuminum cyminum* in mice. Pharmaceut Biol. 2002a;40:478–80.

126. Sayyah M, Peirovi A, Kamalinejad M. Antinociceptive effect of fruit essential oil of *Cuminum cyminum* L. in rat. Iran Biomed J. 2002b;6:141–5.

127. Kubo I, Kinst-Hori I. Tyrosinase inhibitors from cumin. J Agric Food Chem. 1998;46:5338–41.

128. Koppula S, Kopalli SR, Sreemantula S. Adaptogenic and nootropic activities of aqueous extracts of *Carum Carvi* Linn (Caraway) fruit: an experimental study in wistar rats. Aust J Med Herb. 2009;21:76–9.

129. Malini T, Vanithakumari G. Estrogenic activity of *Cuminum cyminum* in rats. Indian J Exp Biol. 1987;25:442–4. [PubMed: 2963791]

130. Thakur S, Bawara B, Dubey A, Nandini D, Chauhan N, Saraf DK. Effect of *Carum carvi* and

*Curcuma longa* on hormonal and reproductive parameter of female rats. Int J Phytomed. 2009;1:31–8.

131. Shirke SS, Jadhav SR, Jagtap AG. Methanolic extract of *Cuminum cyminum* inhibits ovariectomy-induced bone loss in rats. Exp Biol Med. 2008;233:1403–10.

132. Thomson Coon J, Ernst E. Systematic review: Herbal medicinal products for non-ulcer dyspepsia. Aliment Pharmacol Ther. 2002;16:1689–99. [PubMed: 12269960]

133. Forster HB, Niklas H, Lutz S. Antispasmodic effects of some medicinal plants. Planta Med. 1980;40:309–19. [PubMed: 7220648]

134. Al-Essa MK, Shafagoj YA, Mohammed Fi, Afifi FU. Relaxant effect of ethanol extract of *Carum carvi* on dispersed intestinal smooth muscle cells of the guinea pig. Pharm Biol. 2010;48:76–80. [PubMed: 20645759]

135. Hawrelak JA, Cattley T, Myers SP. Essential oils in the treatment of intestinal dysbiosis: A preliminary in vitro study. Altern Med Rev. 2009;14:380–4. [PubMed: 20030464]

136. Nariman F, Eftekhar F, Habibi Z, Massarrat S, Malekzadeh R. Antibacterial activity of twenty iranian plant extracts against clinical isolates of *Helicobacter pylori*. Iran J Basic Med Sci. 2009;12:105–11.

137. Mahady GB, Pendland SL, Stoia A, Hamill FA, Fabricant D, Dietz BM, et al. In vitro susceptibility of *Helicobacter pylori* to botanical extracts used traditionally for the treatment of gastrointestinal disorders. Phytother Res. 2005;19:988–91. [PubMed: 16317658]

138. Nostro A, Cellini L, Di Bartolomeo S, Di Campli E, Grande R, Cannatelli MA, et al. Antibacterial effect of plant extracts against *Helicobacter pylori*. Phytother Res. 2005;19:198–202. [PubMed: 15934015]

139. Khayyal MT, el-Ghazaly MA, Kenawy SA, Seif-el-Nasr M, Mahran LG, Kafafi YA, et al. Antiulcerogenic effect of some gastrointestinally acting plant extracts and their combination. Arzneimittelforschung. 2001;51:545–53. [PubMed: 11505785]

140. Vasudevan K, Vembar S, Veeraraghavan K, Haranath PS. Influence of intragastric perfusion of aqueous spice extracts on acid secretion in anesthetized albino rats. Indian J Gastroenterol. 2000;19:53–6. [PubMed: 10812814]

141. Boskabady MH, Kianai S, Azizi H. Relaxant effect of *Cuminum cyminum* on guinea pig tracheal chains and its possible mechanism(s) Indian J Pharmacol. 2005;37:111–5.

142. Boskabady MH, Kianai S, Azizi H, Khatami T. Antitussive effect of *Cuminum cyminum* Linn. in guinea pigs. Nat Prod Rad. 2006;5:266–9.

143. Srivastava KC. Extracts from two frequently consumed spices--cumin (*Cuminum cyminum*) and turmeric (*Curcuma longa*)--inhibit platelet aggregation and alter eicosanoid biosynthesis in human blood platelets. Prostaglandins Leukot Essen Fatty Acids. 1989;37:57–64.

144. Srivastava KC, Mustafa T. Pharmacological effect of spices: Eicosanoid modulating activities and their significance in human health. Biomed Rev. 1994;2:15–29.

145. Mahesh CM, Gowda KPS, Gupta AK. Protective action of *Cuminum cyminum* against gentamicin-induced nephrotoxicity. J Pharmacy Res. 2010;3:753–7.

146. Sachin BS, Monica P, Sharma SC, Satti NK, Tikoo MK, Tikoo AK, et al. Pharmacokinetic interaction of some antitubercular drugs with caraway: Implications in the enhancement of drug bioavailability. Hum Exp Toxicol. 2009;28:175–84. [PubMed: 19734267]

147. Sachin BS, Sharma SC, Sethi S, Tasduq SA, Tikoo MK, Tikoo AK, et al. Herbal modulation of drug bioavailability: Enhancement of rifampicin levels in plasma by herbal products and a flavonoid glycoside derived from *Cuminum cyminum*. Phytother Res. 2007;21:157–63. [PubMed: 17128432]

148. Venkataramanan RR, Komoroski B, Strom S. *In vitro* and *in vivo* assessment of herb- drug interactions. Life Sci. 2006;27:2105–15. [PubMed: 16427092]

## Figures and Tables

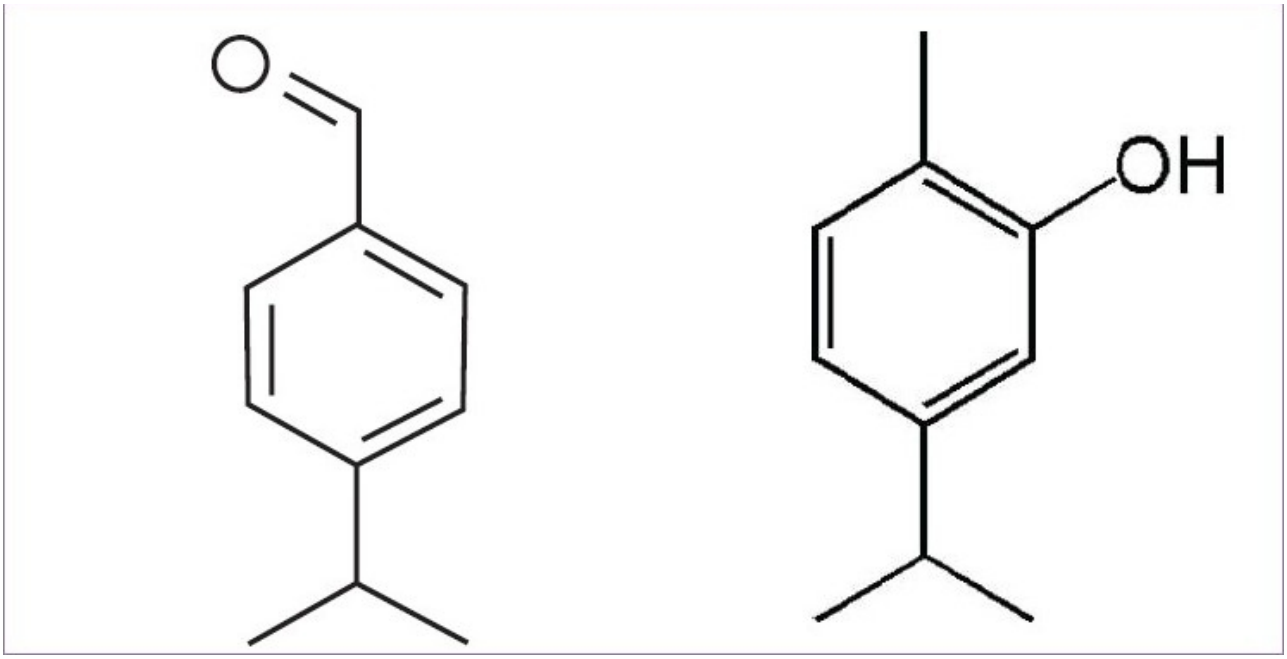
### Figure 1a


Cuminum cyminum

### Figure 1b

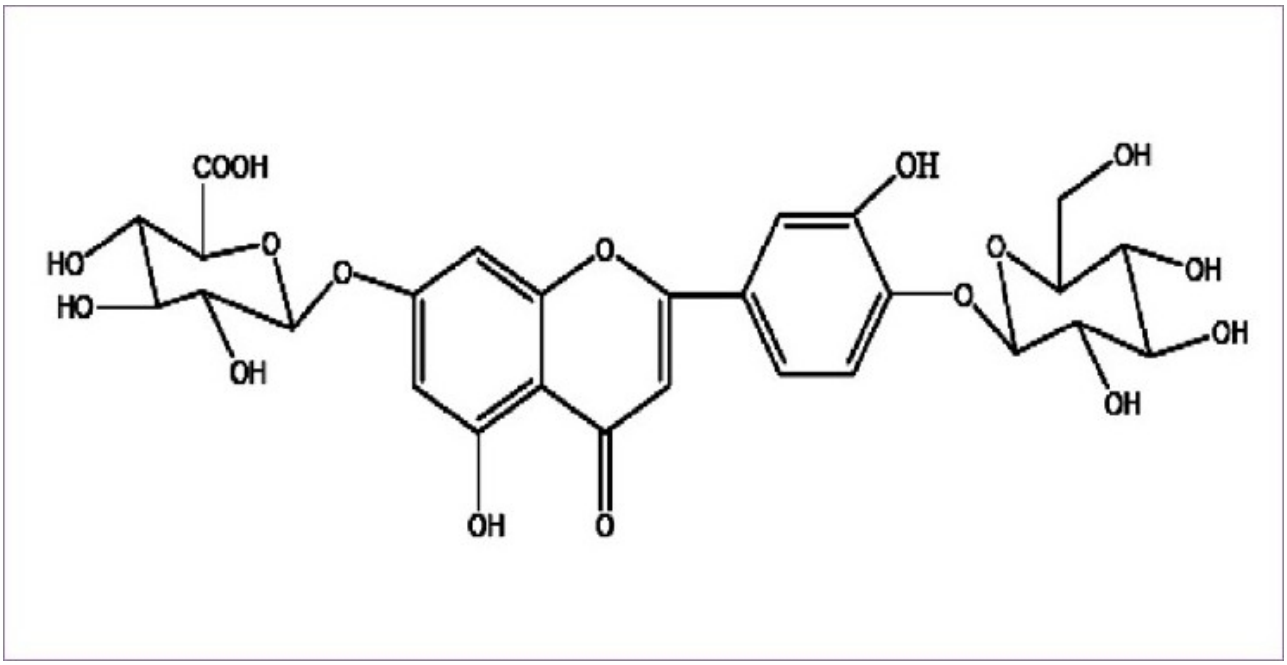

Carum carvi

### Figure 2




(a) Cuminaldehyde, (b) Carvacrol

**Figure 3**




Flavonoid glycoside