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Medical Constituents of Ajwain (*Trachyspermum ammi*) for Human Benefits

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Abstract: Ajwain seed analysis has revealed it to contain fiber (11.9%), carbohydrates (38.6%), tannins, glycosides, moisture (8.9%), protein (15.4%), fat (18.1%), saponins, flavone and mineral matter (7.1%) containing calcium, phosphorous, iron and nicotinic acid. Ajwain fruits yield 2% to 4% brownish essential oil, with thymol as the major constituent (35% to 60%). The non-thymol fraction (thymene) contains para-cymene, γ-terpenine, α- and β-pinenes, dipentene, α-terpinene, and carvacrol. Minute amounts of camphene, myrcene, and α-3-carene also have been found in the plant. Alcoholic extracts contain a highly hygroscopic saponin. From the fruits, an yellow, crystalline flavone and a steroid-like substance has been isolated and it also contains 6-O-β-glucopyranosyloxythymol, glucoside and yields 25% oleoresin containing 12% volatile oil (thymol, γ-terpinene, para-cymene, and α- and β-pinene). The principal oil constituents of T. ammi are carvone (46%), limonene (38%), and dillapiole (9%). Ajwain is administered for curing stomach disorders, a paste of crushed fruits is applied externally for relieving colic pains; and a hot and dry fomentation of the fruits is applied on chest for asthma. Therapeutic uses of T. ammi fruits include; stomachic, carminative and expectorant, antiseptic and amoebiasis, antimicrobial. Seeds soaked in lemon juice with P runus amygdalus (badam) are given in curing amenhorroea and it is also used as antipyretic, febrifugal and in the treatment of typhoid fever. The antihypertensive effect of T. ammi administered intravenously in vivo, and the antispasmodic and bronchodilating actions in vitro showed that calcium channel blockade has been found to mediate the spasmolytic effects of plant materials and it is being considered that this mechanism contributed to their observed result and supported the traditional use of T. ammi in hyperactive disease states of the gut such as colic and diarrhea as well as in hypertension. Ajwain seeds revealed significant reduction of cough number which may be a result of its potent antitussive effect. The bronchodilatory effect of decocted extract of Ajwain on the asthmatic patients' airways was examined in a subsequent trial study. According to the results, the extract has a relatively bronchodilatory effect on asthmatic airways compared to the effect of Theophylline at concentrations used. Ajwain was attributed to have diuretic and antilithiasis activity in ethnopharmacological reports. Accordingly, a human study was performed and in which, seeds of Ajwain were decocted in milk and given orally to volunteers suffering from urinary stone for a nine days period. The results were reported satisfactory against pure ca-oxalate stone. Another activity which has been proved for Ajwain is the antihyperlipidemic property. An in vivo study revealed that Ajwain seeds powder is extensively effective on lipid profile and can decrease total cholesterol, LDL-cholesterol, triglycerides and total lipids. Moreover, organic extract of seeds reduced atherogenic index and increased the level of HDL-cholesterol in albino rabbits. Ajwain was evaluated for the potentiality of antihypertensive and antispasmodic activity. In the related investigation, the aqueous-methanolic extract of the seeds caused a dose dependent decrease in arterial blood pressure in anaesthetized animal models. Furthermore, inhibitory effect on the K+-induced contractions was seen in isolated rabbit aorta and jejunum preparations during the application of Ajwain extract. These findings prove the potential antihypertensive and antispasmodic activity of Ajwain.

Keywords: Bronchodilating; Theophylline; Atherogenic index; Antilithiasis; Antihyperlipidemic.

REVIEW PAPER

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INTRODUCTION

A number of chemical constituents have been reported for the herb. Fiber (11.9%), carbohydrates (24.6%), tannins, glycosides, moisture (8.9%), protein (17.1%), fat (21.1%), saponins, flavones and other components (7.1%) involving calcium, phosphorous, iron, cobalt, copper, iodine, manganese, thiamine, riboflavin and nicotinic acid are of reported

phytochemical constituents of Ajwain (Ranjan *et al*., 2012; Qureshi and Kumar, 2010). In the alcoholic extraction process, a large amount of saponin has been derived (Ranjan *et al*., 2012). Similar to the most species of the family Apiaceae, Ajwain is famous for its brownish essential oil. Apparently, presence of an Ajowan essential oil is responsible for its odor and taste. Hence fruits of Ajwain accumulate up to 5% essential oil in its compartments (Minija and Thoppil, 2002).

However, some investigation reported the yield of fruits essential oil up to 9% which may be considerable. Usually, Thymol is the main Ajwain essential oil constituent and may be yielded from 35% to 60% (Ishikawa *et al*., 2001; Zarshenas *et al*., 2014).

The non-thymol fraction (Thymene) contains Para-cymene, Gamma-terpinene, Alpha-pinene, Beta-pinene, α-terpinene, Styrene, Delta-3-carene, Beta-phyllanderene, terpinene-4-ol and Carvacrol (Ranjan *et al*., 2012; Mohagheghzadeh *et al*., 2005). On the other hand, in an investigation, carvone (46.2%), limonene (38.1%) and dillapiole (8.9%) were introduced as principal oil constituents. Also oleic, linoleic, palmitic, petroselinic acid, resin acids are isolated from fruits of Ajwain (Qureshi and Kumar, 2010). New glycosyl constituents such as 6-hydroxycarvacrol2-O-β-D-Glucopyranosideand3,5-Dihydroxytoluene3-O-β-DGalactopyranoside are recently reported from fruits of Ajwain.

In order to evaluate the analgesic and antinociceptive activity of Ajwain, an In vivo investigation was carried out using a Tail-flick Analgesio meter Device (Dashti-Rahmatabadi *et al*., 2007). The study revealed that the ethanolic extract significantly increase in Tail-Flick Latency (TFL) within 2 hours post-drug administration. An experimental trial study has also been carried out to compare the antinociceptive effect of the hydroalcoholic extract of Ajwain with morphine sulphate using formalin test. Findings revealed that Ajwain extract exhibited antinociceptive effect on both early and late phases (Hejazian *et al*., 2008). Similar study has been done on the Ajwain total essential oil which was significantly effective on the late phase of formalin test (Hejazian, 2006) and it may be due to the presence of thymol in essential oil. In addition, under a randomized controlled placebo control clinical trial, the herb essential oil was assayed for the analgesic effect in neuropathic feet burn. Results revealed that Ajwain essential oil significantly reduced the feet burn compared to placebo (Petramfar *et al*., 2013). To assay the antibacterial efficacy of Ajwain, acetone and aqueous extracts were tested against Enterococcus faecalis, Escherichia coli, Klebsiella pneumonia, Pseu-domonas aeruginosa, Salmonella typhi, Salmonella typhi-murium, Shigella flexneri, and Staphylococcus aureususing agar diffusion assay (Kaur and Arora, 2008). The study showed that acetone extract shows more activity compared to the aqueous extract. In another study, ethanolic extract of Ajwain possessed antibacterial activity against eight strains of Helicobacter pylori (Zaidi *et al*., 2009). Also methanolic extract of Ajwain exhibited bactericidal activity against 11 species at 2mg/well in agar well-diffusion method. It was measured by Diameter of Inhibition Zones (DIZ). DIZ was over 15mm against Staphylococcus aureus and Staphylococcus epidermidis; 10–14 mm against Pseudomonas aeruginosa and Bacillus pumilus; 7–9 mm against Escherichia coli, Klebsiella pneumonia as well as Bordetella bronchiseptica. On the other hand, no activity was reported against Pseudomonas fluorescens and Micrococcus luteus (Shahidi, 2004).

It is reported that the essential oil extracted from the seeds of Ajwain can exhibit insecticidal activity in the oviposition step as well as egg hatching and developmental inhibitory activities against Callosobruchus chinensis (Chaubey, 2008; Kostyukovsky *et al*., 2002). A bioassay-guided fractionation was prepared by introducing the crude extract to flash chromatography. HPLC analysis was done for both crude extract and active fraction (Mathew *et al*., 2008). Antihelmintic activity of Ajwain was carried out by considering the Haemonchus contortus in sheep and Ascaris lumbricoidesin humans. Results were due to loss of energy reserves by interference with the energy metabolism of parasites through potentiating the ATPase activity. Ajwain has also been reported to exhibit cholinergic activity with peristaltic movements of gut. Hence this fact may help in expulsion of intestinal parasites and be a contributory factor to its anthelmintic activity (Tamura and Iwamoto, 2004; Jabbar *et al*., 2006).

Ajwain was also evaluated for its nematicidal activity. A survey was done on the total essential oil components of Ajwain that showed significant nematicidal activity against pinewood nematode, Bursaphelenchus xylo-philus. Nematicidal activity of Ajwain essential oils LC50values was measured as 0.431mg/ml (Park *et al*., 2007) and it was mainly attributed to the activity of Thymol and Carvacrol.

Ajwain was also evaluated for exhibiting anti–inflammatory effect. Accordingly, both total alcoholic extract and total aqueous extract possess in vivo significant anti–inflammatory effect (Thangam and Dhananjayan, 2005).

Ajwain seeds revealed significant reduction of cough number which may be a result of its potent antitussive effect (Boskabady and Shaikhi, 2000). Relative studies showed the inhibitory effect of both Ajwain extract and essential oil on Histamine (H1) receptors of isolated guinea-pig tracheal chains (Boskabady and Shaikhi, 2000). In another study, in the field of respiratory, bronchodilatory effects of different fractions of Ajwain essential were examined. Results showed that the relaxant and bronchodilatory effect of

essential oil fractions may be due to the amount of Carvacrol (Boskabady *et al*., 2003).

The bronchodilatory effect of decocted extract of Ajwain on the asthmatic patients' airways was examined in a subsequent trial study. According to the results, the extract has a relatively bronchodilatory effect on asthmatic airways compared to the effect of Theophylline at concentrations used (Boskabady *et al*., 2007).

Ajwain was attributed to have diuretic and anti-lithiasis activity in ethnopharmacological reports. Accordingly, a human study was performed and in which, seeds of Ajwain were decocted in milk and given orally to volunteers suffering from urinary stone for a nine days period. The results were reported satisfactory against pure ca-oxalate stone (Sabar, 2010).

Another activity which has been proved for Ajwain is the antihyperlipidemic property. An in vivo study revealed that Ajwain seeds powder is extensively effective on lipid profile and can decrease total cholesterol, LDL-cholesterol, triglycerides and total lipids. Moreover, organic extract of seeds reduced atherogenic index and increased the level of HDL-cholesterol in albino rabbits (Javed *et al.*, 2006).

Detoxification of aflatoxins by seed extract of Ajwain can support the related traditional reports. Hence in an experimental study, Ajwain seed extract exhibited the maximum degradation of aflatoxin G1 (Velazhahan *et al*., 2010).

The antioxidant and ameliorative property of Ajwain extract has been evaluated on hexachlorocyclohexane induced oxidative stress and toxicity in an in vivo investigation. Accordingly, results revealed that the dietary Ajwain extract would reduce the toxicity resulted from hepatic free radical stress (Anilakumar *et al*., 2008).

For the evaluation of Ajwain antiviral activity, an in vitro assay was carried out on the methanolic extract of the herb which showed significant inhibitory effects on Hepatitis C Virus (HCV) protease (Hussein *et al*., 2000).

The extract also possessed preventive effects against CCl_4-induced prolongation of pentobarbital sleeping time as well as equilibrating the level of hepatic enzymes, Alkaline Phosphatase (ALP) and Aminotransferases (AST and ALT) during liver damage (Gilani *et al*., 2005). Using different ulcer models, Ajwain ethanolic extract resulted in significant ulcer index decrease in animal pre-treated with and also exhibited ulcer protection in all models. Overall, the extract reduced the ulcerative lesions compared to control group of animal model (Ramaswamy *et al*., 2010). Ajwain was evaluated for the potentiality of antihy- pertensive and antispasmodic activity. In the related investigation, the aqueous-methanolic extract of the seeds caused a dose dependent decrease in arterial blood pressure in anaesthetized animal models. Furthermore, inhibitory effect on the K+-induced contractions was seen in isolated rabbit aorta and jejunum preparations during the application of Ajwain extract.

Traditional practitioners recommended the herb as a digestive stimulant medicine. It is now proved that Ajwain can increase the secretion of gastric acid, bile acids and activity of digestive enzymes. It may also reduce the food transient time (Vasudevan *et al*., 2000; Platel and Srinivasan, 2001). As the enzyme modulatory activity, Ajwain reinforced the pancreatic lipase and amylase effectiveness, which may support the digestive stimulant activity (Ramakrishna *et al*., 2003).

C. copticum or Ajwain belongs to the Apiaceae plants family and its seeds are used extensively as a food additive in India and mainly therapeutically effective, with hot nature. C. copticumis an Egyptian aborigine plant. This plant grows in arid and semiarid fields in different regions of central Europe, Asia, India (most crops are in the states of Rajasthan, Gujarat, and West Bengal), Iran (especially eastern regions of\ Baluchistan), Iraq, Afghanistan, and Pakistan (Zahin *et al*., 2010).

In traditional medicine, different therapeutic applications for C. copticum have been described and in Persian traditional medicine it is used for thousands of years. The bronchodilatory, antitussive, and antidyspnea effects were demonstrated for C. copticum. The therapeutic effects of this plant in gastrointestinal disorders, such as reflux, cramps, abdominal tumors, abdominal pain, and Helicobacter pylori, as well as in eye infection disorders, have been demonstrated (Zarshenas *et al*., 2013).

Therapeutic uses of C. copticum seeds also include carminative, antiseptic, amoebiasis expectorant, antimicrobial, antiparasitic, antiplatelet-aggregatory, and antilithiasis as well as treating common cold and acute pharyngitis. Abortifacient, galactogogic, and diuretic activities have been observed for this plant (Chauhan *et al*., 2012; Ranjan, 2011). There is also anticarcinogenic potential evidence for C. copticum (Lim, 2013). It has been shown that this plant has also foetotoxicity, abortion potential, and galactogogue properties (Jeet *et al*., 2012).

Different names of the plant in various languages (ver-nacular name) are Sanskrit: Yamini, Assamese language: Jain, English: Bishop's weed, Hindi, Baluchi: Ajowan and Spirca, Gujarati Language: Ajmo, Canada: Oma, Malaysia: Oman, Arabic: Khella or khellin, Persian: nankhah, zenian, khordaneh, and South Khorasan: ajgho (Brito-Arias, 2007).

The constituents of the seed of C. copticum included carbohydrates (38.6%), fat (18.1%), protein (15.4%), fiber (11.9%), tannins, glycosides, moisture (8.9%), saponins, flavone, and mineral matter (7.1%) containing calcium, phosphorous, iron, cobalt, copper, iodine, manganese, thiamine, riboflavin, and nicotinic acid (Bairwa *et al*., 2012). C. copticum grows indifferent areas of the world containing different compounds. Main components of the oil of Iranian and African C. copticum oil are carvacrol, -terpinene, and p-cymene while thymol (97.9%) is the main component of south Indian plant oil. It was also reported that thymol (45.9%), γ-terpinene (20.6%), and o-cymene (19%) are the major components of the oil of C. copticum but ethylene methacrylate (6.9%), β-pinene (1.9%), and hexadecane (1.1%) were the other constituents of the plant (Mahboubi and Kazempour, 2011). Thymol (72.3%), terpinolene (13.12%), and o-cymene (11.97%) were also identified as constituents of C. copticum (Kazemi *et al*., 2011). Chemical composition of C. copticum in two areas in Iran was assessed and results showed that the plant in Kam-firuz containsγ-terpinene (48.07%), p-cymene (33.73%), and thymol (17.41%) compared to the composition of plant in Eghlid area which includedγ-terpinene (50.22%), p-cymene (31.90%), and nerolidol (4.26%) as main components (Zomorodian *et al*., 2011).

Chemical constituents of the essential oil of C. copticum and its acetone extract were also examined by GC and GC-MS analysis. Results showed that 96.3% of the total amount of the essential oil contains 26 components including thymol (39.1%), p-cymene (30.8%), γ-terpinene (23.2%), β-pinene (1.7%), and terpinene-4-ol (0.8%) while 68.8% of the total amount of its acetone extract has thymol (39.1%), oleic acid (10.4%), linoleic acid (9.6%), γ-terpinene (2.6%), p-cymene (1.6%), palmitic acid (1.6%), and xylene (0.1%) (Singh *et al*., 2004). Hydrodistillation and supercritical fluid (CO_2) extraction (SFE) methods of the plant were also performed. In hydrodistilled oil, therewere 8 components including thymol (49.0%), γ-terpinene (30.8%), p-cymene (15.7%), b-pinene (2.1%), myrcene (0.8%), and limonene (0.7%), but in SFE method with the best condition of temperature, pressure, and dynamic extraction time there were 3 components including γ-terpinene (14.2%), p-cymene (23.1%), and thymol (62.0%) (Khajeh *et al*., 2004).

Trachyspermum ammi L. belonging to family Apiaceae is a highly valued medicinally important seed spice. The roots are diuretic in nature and the seeds possess excellent aphrodisiac properties. The seeds contain 2–4.4% brown colored oil known as ajwain oil. The main component of this oil is thymol, which is used in the treatment of gastro-intestinal ailments, lack of appetite and bronchial problems. The oil exhibits fungicidal, antimicrobial and anti-aggregatory effects on humans (Singh and Singh, 2000).

Ajwain is a traditional potential herb and is widely used for curing various diseases in humans and animals. The fruit possesses stimulant, antispasmodic and carminative properties. It is an important remedial agent for flatulence, atonic dyspepsia and diarrhea. The seed of ajwain is bitter, pungent and it acts as anthelmintic, carminative, laxative, and stomachic. It also cures abdominal tumors, abdominal pains and piles. Seeds contain an essential oil containing about 50% thymol which is a strong germicide, anti-spasmodic and fungicide. Thymol is also used in toothpaste and perfumery (Joshi, 2000).

It is widely grown in arid and semi-arid regions where soils contain high levels of salts (Ashraf, 2002; Munns, 2002).

Ajwain is a profusely branched annual herb, 60-90 cm tall. Stem is striated; inflorescence compound umbel with 16 umbellets, each containing up to 16 flowers; flowers actinomorphic, white, male and bisexual; corolla 5, petals bilobed; stamens 5, alternating with the petals; ovary inferior; stigma knob-like; fruit aromatic, ovoid, cordate, cremocarp with a persistent stylopodium; leaves pinnate, with a terminal and 7 pairs of lateral leaflets (Joy *et al*., 2001).

Fruit, consists of two mericarps, grayish brown, ovoid, compressed, about 2 mm long and 1.7 mm wide, 5 ridges and 6 vittae in each mericarp, usually separate, 5 primary ridges. Ajwain seed analysis has revealed it to contain fiber (11.9%), carbohydrates (38.6%), tannins, glycosides, moisture (8.9%), protein (15.4%), fat (18.1%), saponins, flavone and mineral matter (7.1%) containing calcium, phosphorous, iron and nicotinic acid. Ajwain fruits yield 2% to 4% brownish essential oil, with thymol as the major constituent (35% to 60%). The nonthymol fraction (thymene) contains para-cymene, γ-terpenine, α- and β-pinenes, dipentene, α-terpinene, and carvacrol. Minute amounts of camphene, myrcene, and α-3-carene also have been found in the plant. Alcoholic extracts contain a highly hygroscopic saponin. From the fruits, a yellow, crystalline flavone and a steroid-like substance has been isolated and it also contains 6-O-β-glucopyranosyloxythymol, glucoside and yields 25% oleoresin containing 12% volatile oil (thymol, γ-terpinene, para-cymene, and α- and β-pinene) (Nagalakshm *et al*., 2000).

The principal oil constituents of T. ammiare carvone (46%), limonene (38%), and dillapiole (9%) (Ishikawah *et al*., 2001).

In Indian system of medicine, ajwain is administered for curing stomach disorders, a paste of crushed fruits is applied externally for relieving colic pains; and a hot and dry fomentation of the fruits is applied on chest for asthma (Singh *et al*., 2003).

T. ammi has been shown to possess antimicrobial, (Bonjar, 2004) hypolipidemic, digestive stimulant, (Vasudevan *et al*., 2000) antihypertensive, hepatoprotective, antispasmodic, broncho-dilating, (Gilani *et al.*, 2003) antilithiasis,diuretic,abortifacient,galactogogic,antiplatel et-aggregatory, antiinflammatory, (Thangamand Dhananjayan, 2003) antitussive (Boskabady *et al*., 2003) antifilarial, (Mathew *et al*., 2008) gestroprotective, (Ramaswamy *et al*., 2008) nematicidal, anthelmintic, (Priestley *et al*., 2003) detoxification of aflatoxins, (Velazhahan *et al*., 2010) and ameliorative effects (Anilakumar *et al*., 2009). Therapeutic uses of T. ammifruits include; stomachic, carminative and expectorant, antiseptic and amoebiasis, antimicrobial. Seeds soaked in lemon juice with P runus amygdalus (badam) are given in curing amenhorroea and it is also used as antipyretic, febrifugal and in the treatment of typhoid fever.

The antihypertensive effect of T. ammi administered intravenously in vivo, and the antispasmodic and broncho-dilating actionsin vitro showed that calcium channel blockade has been found to mediate the spasmolytic effects of plant materials and it is being considered that this mechanism contributed to their observed result and supported the traditional use of T. ammi in hyperactive disease states of the gut such as colic and diarrhea as well as in hypertension (Gilani *et al*., 2003). The hepatoprotective actions in vivo showed that T. Ammi was 80% protective in mice against a normally-lethal dose of paracetamol (1g/kg), it prevented the CCl_4-induced prolongation of pentobarbital sleeping time in mice, and it tended to normalize the high serum levels of liver enzymes caused by CCl_4-induced liver damage in rats (Gilani *et al*., 2003).

Anti-inflammatory potential of the total alcoholic extract (TAE) and total aqueous extract (TAQ) of the Ajwain seeds was determined. TAE and TAQ exhibited significant ($P<0.001$) antiinflammatory activity in both the animal models. The weights of the adrenal glands were found to be significantly increased in TAE and TAQ treated animals. TAE and TAQ extracts from the ajwain seeds exhibit significant anti-inflammatory potential (Thangam and Dhananjayan, 2003).

The antitussive effects of aerosols of two different concentrations of aqueous and macerated extracts and carvacrol, codeine, and saline were tested by counting the number of coughs produced. The results showed significant reduction of cough number obtained in the presence of both concentrations of aqueous and macerated extracts and codeine ($P < 0.001$ for extracts and $P < 0.01$ for codeine) (Boskabady *et al*., 2003). In vitro activity of the methanolic extract of the fruits of Trachyspermum ammi (Apiaceae) against Setaria digitata worms has been investigated. The crude extract and the active fraction showed significant activity against the adult S. digitata by both a worm motility and MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] reduction assays. The isolated active principle phenolic monoterpene screened for in vivo antifilarial activity against the human filarial worm B. malayi in Mastomys coucha showed macrofilaricidal activity and female worm sterility in vivo against B. malayi. T. ammi crude extract exhibited macrofilaricidal activity. The IC50 values for the isolated active principle 2- isopropyl-5-methyl phenol at two incubation periods 24 and 48 h were 0.024 and 0.002 mg/ml, respectively. The in vivo effect of the active principle 2-isopropyl-5-methyl phenol was evaluated against the B. malayi parasite in a Mastomys coucha model. The mean percentage mortality of adults (58.93%) in the group treated with 50 mg/kg was significantly ($P<0.0001$) higher than that was obtained in the control group (19.05%) (Mathew *et al*., 2008). Trachyspermum ammi fruit showed antiulcer activity by using different ulcer models. Animals pre-treated with ethanolic extract showed significant decrease in ulcer index and percentage ulcer protection in all models. The results suggest that the extract showed significant protection ($p<0.001$) by reducing ulcerative lesions when compared with control group of animals (Ramaswamy *et al*., 2008). The seed extract of ajwain showed the maximum degradation of aflatoxin G1 (AFG1). The aflatoxin detoxifying activity of the seeds extract was significantly reduced upon boiling. Significant levels of degradation of other aflatoxins viz., AFB1, AFB2 and AFG2 by the dialyzed seeds extract were also observed. Time course study of AFG1 detoxification by dialyzed T. ammi extract showed that more than 91% degradation occurred at 24 h and 78% degradation occurred within 6 h after incubation (Velazhahan *et al*., 2010).

Effects of ajwain extract on hexachlorocyclohexane (HCH)-induced oxidative stress and toxicity in rats were investigated. Pre-feeding of ajwain extract resulted in increased GSH, GSH-peroxidase, G-6-PDH, SOD, catalase, glutathione S-transferase (GST) activities and decreased hepatic levels of lipid peroxides. It was concluded that HCH administration resulted in hepatic free radical stress, causing toxicity, which could be reduced by the dietary ajwain extract (Anilakumar *et al*., 2009).

Thymol kills the bacteria resistant to even prevalent third generation antibiotics and multi-drug resistant microbial pathogens and thus works as a plant based 4^{th} generation herbal antibiotic formulation (Khanuja, 2004).

Phenolic compounds, such as thymol and carvacol, are known to be either bactericidal or bacteriostatic agents depending on the concentration used (Caccioni *et al*., 2000). Hypolipidemic action in vivo Antihyperlipidemic effect of T. ammi seed has been obtained in albino rabbits. It was assessed that T. ammi powder at a dose rate of 2 g/kg body weight and its

equivalent methanol extract were extensively effective in lipid lowering action by decreased total cholesterol, LDL-cholesterol, triglycerides and total lipids (Javed *et al*., 2002). In experimental rats in vivo, the addition of T. ammi to the diet reduced food transit time and also enhanced the activity of digestive enzymes and/or caused a higher secretion of bile acids (Platel and Srinivasan, 2001).

Pine Wilt disease is caused by the pinewood nematode (PWN), Bursaphelenchus xylophilus. Nematicidal activity of ajwain oil constituents (camphene, pinene, myrcene, limonene, terpinene, terpinen- 4-ol, thymol and carvacrol) is against PWN. Hydrochloride and morantal tatrate. (Murthy *et al*., 2009) Amino and hydroxyl groups have been hypothesized as target sites of methyl isothiocyanate in nematodes (Singh *et al*., 2004). Some essential oils have been reported to interfere with the neuromodulator octopamine (Choi *et al*., 2007) or GABA-gated chloride channels of insect pests (Kong *et al*., 2006). Thymol and carvacrol are very effective against PWN. These studies confirm that the nematicidal activity of ajwain oil is mainly attributed to the activity of thymol and carvacrol. Nematicidal activity of ajwain essential oils LC50 values was 0.431 mg/ml (Kwon *et al*., 2007). Anthelmintic activity of T. ammi shows its effect against specific helminths, e.g. Ascaris lumbricoides in humans and Haemonchus contortus in sheep (Kwon *et al*., 2007). Anthelmintic activity of T. ammi exerts (Kostyukovsky *et al*., 2002). The plant has also been reported to possess holinergic activity with peristaltic movements of the gut, thus helping in expulsion of intestinal parasia contributory factor to its anthelmintic activity (Tamurab and Iwamoto, 2004; Jabbar *et al*., 2006).

REFERENCES

- Anilakumar, K. R., Saritha, V., Khanum, F., & Bawa, A. S. (2009). Ameliorative effect of ajwain extract on hexachlorocyclohexane-induced lipid peroxidation in rat liver. *Food and chemical toxicology*, *47*(2), 279-282. doi: 10.1016/j.fct.2008.09.061
- Ashraf, M. (2002). Salt tolerance of cotton: some new advances. *Critical Reviews in Plant Sciences*, *21*(1), 1-30.
- Bairwa, R., Sodha, R. S., & Rajawat, B. S. (2012). Trachyspermum ammi. *Pharmacognosy reviews*, *6*(11), 56-60.
- Bonjar, G. H. (2004). Anti yeast activity of some plants used in traditional herbal medicine of Iran. *J Biol Sci*, *4*(212), 5.
- Boskabady, M. H., Alizadeh, M., & Jahanbin, B. (2007). Bronchodilatory effect of Carum copticum in airways of asthmatic patients. *Therapie*, *62*(1), 23-29.
- Boskabady, M. H., Jandaghi, P., Kiani, S., & Hasanzadeh, L. (2005). Antitussive effect of Carum copticum in guinea pigs. *Journal of ethnopharmacology*, *97*(1), 79-82.
- Boskabady, M. H., Ramazani, M., & Tabei, T. (2003). Relaxant effects of different fractions of essential oil from Carum copticum on guinea pig tracheal chains. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *17*(10), 1145-1149.
- Boskabady, M. H., & Shaikhi, J. (2000). Inhibitory efcopticumon Histamine (H1) receptors of isolated guinea-pig tracheal chains. *J Ethnopharmacol, 69*(3), 217–227. doi:10.1016/S0378-8741(99)00116-6
- Brito-Arias, M. (2007). Synthesis and Characterization of Glycosides, Springer, NewYork, NY, USA.
- Caccioni, D. L., Guizzardi, M., & Biondi, D. M. (2000). Relationships between volatile components of citrus fruit essential oil and antimicrobial action on Penicillium digitatum and Penicillium italicum. *Int J Food Microbiol*, 88, 170-175.
- Chaubey, M. K. (2008). Fumigant toxicity of essential oils from some common spices against pulse beetle, Callosobruchus chinensis (Coleoptera: Bruchidae). *Journal of oleo science*, *57*(3), 171-179.
- Chauhan, B., Kumar, G., & Ali, M. (2012). A review on phytochemical constituents and activities of Trachyspermum ammi (L.) Sprague fruits. *AJPTR*, *2*(4), 329-340.
- Choi, I. H., Shin, S. C., & Park, I. K. (2007). Nematicidal activity of onion (Allium cepa) oil and its components against the pine wood nematode (Bursaphelenchus xylophilus). *Nematology*, *9*(2), 231-235.
- Dashti-Rahmatabadi, M. H., Hejazian, S. H., Morshedi, A., & Rafati, A. (2007). The analgesic effect of Carum copticum extract and morphine on phasic pain in mice. *Journal of ethnopharmacology*, *109*(2), 226-228.
- Gilani, A. H., Jabeen, Q., Ghayur, M. N., Janbaz, K. H., & Akhtar, M. S. (2005). Studies on the antihypertensive, antispasmodic, bronchodilator and hepatoprotective activities of the Carum copticum seed extract. *Journal of Ethnopharmacology*, *98*(1-2), 127-135.
- Hejazian, S. H. (2006). Analgesic effect of essential oil (EO) from Carum copticum in mice. *World J Med Sci*, *1*(2), 95-99.
- Hejazian, S. H., Mosaddegh, M. H., & Dashti Rahmatabadi, H. (2008). Antinociceptive effects of Carum copticum extract in mice using formalin test. *World Appl Sci J*, *3*(2), 215-219.
- Hussein, G., Miyashiro, H., Nakamura, N., Hattori, M., Kakiuchi, N., & Shimotohno, K. (2000). Inhibitory effects of Sudanese medicinal plant extracts on hepatitis C virus (HCV) protease. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *14*(7), 510-516.
- Ishikawa, T., Sega, Y., & Kitajima, J. (2001). Water-soluble constituents of ajowan. *Chemical and pharmaceutical bulletin*, *49*(7), 840-844.
- Jabbar, A., Iqbal, Z., & Khan, M. N. (2006). In vitro anthelmintic activity of Trachyspermum ammi seeds. *Pharmacognosy magazine*, *2*(6), 126-129.

- Javed, I., Iqbal, Z., Rahman, Z. U., Khan, F. H., Muhammad, F., Aslam, B., & Ali, L. (2006). Comparative antihyperlipidaemic efficacy of Trachyspermum ammi extracts in albino rabbits. *Pakistan Veterinary Journal*, *26*(1), 23-29.
- Javed, I. M., Akhtar, T., Khaliq, M. Z., Khan, G., & Muhammad, M. (2002). Antihyperlipidaemic effect of Trachyspermum ammi (Ajwain) in rabbits. In: Faisalabad: Proc 33rd All Pakistan Science Conference University of Agriculture; p. 80-81.
- Jeet, K., Devi, N., Narender, T., Sunil, T., Lalit, S., & Raneev, T. (2012). Trachyspermum ammi (ajwain): a comprehensive review. *International research Journal of pharmacy*, *3*(5), 133-138.
- Joshi, S. G. (2000). Medicinal Plants. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.; p. 47.
- Joy, P. P., Thomas, J., Mathew, S., Jose, G., & Joseph, J. (2001). Aromatic plants. Tropical Horticulture. Bose, T. K., Kabir, J., Das, P., Joy, P. P., editors. Vol. 2. Calcutta: Naya Prokash; p. 633-733.
- Kaur, G. J., & Arora, D. S. (2008). In vitro antibacterial activity of three plants belonging to the family Umbelliferae. *International Journal of Antimicrobial Agents*, *31*(4), 393-395.
- Kazemi Oskuee, R., Behravan, J., & Ramezani, M. (2011). Chemical composition, antimicrobial activity and antiviral activity of essential oil of Carum copticum from Iran. *Avicenna Journal of Phytomedicine*, *1*(2), 83-90.
- Khajeh, M., Yamini, Y., Sefidkon, F., & Bahramifar, N. (2004). Comparison of essential oil composition of Carum copticum obtained by supercritical carbon dioxide extraction and hydrodistillation methods. *Food chemistry*, *86*(4), 587-591.
- Khanuja, S. P. (2004). Formulation Comprising Thymol useful in the Treatment of Drug Resistance Bacterial infection, CCIR, New Delhi, United state patent no US 6,824,795 b2.
- Kong, J. O., Lee, S. M., Moon, Y. S., Lee, S. G., & Ahn, Y. J. (2006). Nematicidal activity of plant essential oils against Bursaphelenchus xylophilus (Nematoda: Aphelenchoididae). *Journal of Asia-Pacific Entomology*, *9*(2), 173-178.
- Kostyukovsky, M., Rafaeli, A., Gileadi, C., Demchenko, N., & Shaaya, E. (2002). Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: possible mode of action against insect pests. *Pest Management Science: formerly Pesticide Science*, *58*(11), 1101-1106.
- Kwon Park, Il., Junheon, K., & Sang-Gil, L. (2007). Nematicidal Activity of Plant Essential Oils and Components From Ajwain (Trachyspermum ammi), Allspice (Pimenta dioica) and Litsea (Litsea cubeba) Essential Oils Against Pine Wood Nematode (Bursaphelenchus Xylophilus). *J Nematol*, 39, 275-279.
- Lim, T. K. (2013). Edible Medicinal and Non-Medicinal Plants, vol.5, Springer, NewYork, NY, USA.
- Mahboubi, M., & Kazempour, N. (2011). Chemical composition and antimicrobial activity of Satureja hortensis and Trachyspermum copticum essential oil. *Iranian journal of microbiology*, *3*(4), 194-200.
- Mathew, N., Misra-Bhattacharya, S., Perumal, V., & Muthuswamy, K. (2008). Antifilarial lead molecules isolated from Trachyspermum ammi. *Molecules*, *13*(9), 2156-2168.
- Minija, J., & Thoppil, J. E. (2002). Essential oil composition of Trachyspermum ammi (l.) sprague from South India. *Indian Journal of pharmaceutical sciences*, *64*(3), 250-251.
- Mohagheghzadeh, A., Faridi, P., & Ghasemi, Y. (2007). Carum copticum Benth. & Hook., essential oil chemotypes. *Food Chemistry*, *100*(3), 1217-1219. doi: 10.1016/j.foodchem.2005.12.002
- Munns, R. (2002). Comparative physiology of salt and water stress. *Plant, cell & environment*, *25*(2), 239-250.
- Murthy, P. S., Borse, B. B., Khanum, H., & Srinivas, P. (2009). Inhibitory effects of Ajowan (Trachyspermum ammi) ethanolic extract on A. ochraceus growth and ochratoxin production. *Turkish Journal of Biology*, *33*(3), 211-217.
- Nagalakshmi, S., Shankaracharya, N. B., Naik, J. P., & Rao, L. J. M. (2000). Studies on chemical and technological aspects of ajowan (Trachyspermum ammisyn. Carum copticum). *J Food Sci Technol*, 37, 277-281.
- Park, I. K., Kim, J., Lee, S. G., & Shin, S. C. (2007). Nematicidal activity of plant essential oils and components from Ajwan (Trachyspermum ammi), Allspice (Pimenta dioica) and Litsea (Litsea cubeba) essential oils against pine wood nematode (Bursaphelenchus Xylophilus). *J Nematol*, *39*(3), 275-279.
- Petramfar, P., Moein, M., Semani, S., & Zarshenas, M. M. (2013). Ajwain 10% o/w cream versus placebo in feet burning; a randomized, double-blind, placebo-controlled trial. *Iranian Journal of Neurology*, *12*(1), 61.
- Platel, K., & Srinivasan, K. (2001). Studies on the influence of dietary spices on food transit time in experimental rats. *Nutrition Research*, *21*(9), 1309-1314.
- Priestley, C. M., Williamson, E. M., Wafford, K. A., & Sattelle, D. B. (2003). Thymol, a constituent of thyme essential oil, is a positive allosteric modulator of human GABAA receptors and a homo-oligomeric GABA receptor from Drosophila melanogaster. *British journal of pharmacology*, *140*(8), 1363-1372.
- Qureshi, A. A., & Kumar, K. E. (2010). Phytochemical constituents and pharmacological activities of Trachyspermum ammi. *Plant Archives*, *10*(2), 955-959.
- Ramakrishna Rao, R., Platel, K., & Srinivasan, K. (2003). In vitro influence of spices and spice-active principles on digestive enzymes of rat pancreas and small intestine. *Food/Nahrung*, *47*(6), 408-412.
- Ramaswamy, S., Sengottuvelu, S., Haja Sherief, S., Jaikumar, S.., Saravanan, R., & Prasadkumar, C. (2010). Gastroprotective activity of ethanolic extract of Trachyspermum AmmiFruit. *International Journal of Pharma and Bio Sciences*, *1*(1), 1-15.

- Ranjan, B., Manmohan, S., Singh, S. R., & Singh, R. B. (2012). Medicinal uses of Trachyspermum ammi: a review. *Pharmacogn Rev*, *6*(11), 56–60.
- Sabar, A. G. (2010). Lithotripsy of different urinary tract stones by using seeds of Carum copticum. *Iraqi Journal of Pharmaceutical Sciences*, *19*(2), 38-41.
- Bonjar, S. (2004). Evaluation of antibacterial properties of some medicinal plants used in Iran. *Journal of ethnopharmacology*, *94*(2-3), 301-305.
- Singh G, Maurya S, Catalan C. Chemical, antifungal, antioxidative studies of Ajwain oil and its acetone extract. J Agric Food Chem 2004; 52: 3292-6.
- Singh, G., Maurya, S., Catalan, C., & De Lampasona, M. P. (2004). Chemical constituents, antifungal and antioxidative effects of ajwain essential oil and its acetone extract. *Journal of agricultural and food chemistry*, *52*(11), 3292-3296.
- Ishwar, S., & Singh, V. P. (2000). Antifungal properties of aqueous and organic solution extracts of seed plants against Aspergillus flavus and A. niger. *Phytomorphology*, *50*(2), 151-157.
- Singh, V. K., Singh, S., & Singh, D. K. (2003). Pharmacological effects of spices. In Recent Progress in Medicinal Plants. Phytochemistry Pharmacology. Vol. 2. Houston, Texas, USA: Stadium Press; p. 321-353.
- Tamura, T., & Iwamoto, H. (2004). Thymol: a classical small-molecule compound that has a dual effect (potentiating and inhibitory) on myosin. *Biochemical and biophysical research communications*, *318*(3), 786-791.
- Tamura, T., & Iwamoto, H. (2004). Thymol: a classical small-molecule compound that has a dual effect (potentiating and inhibitory) on myosin. *Biochemical and biophysical research communications*, *318*(3), 786-791.
- Boskabady, M. H., Jandaghi, P., Kiani, S., & Hasanzadeh, L. (2005). Antitussive effect of Carum copticum in guinea pigs. *Journal of ethnopharmacology*, *97*(1), 79-82. doi: 10.1016/j.jep.2004.10.016
- Thangam, C., & Dhananjayan, R. (2003). Antiinflammatory potential of the seeds of Carum Copticum Linn. *Indian Journal of pharmacology*, *35*(6), 388-391.
- Vasudevan, K., Vembar, S., Veeraraghavan, K., & Haranath, P. S. (2000). Influence of intragastric perfusion of aqueous spice extracts on acid secretion in anesthetized albino rats. *Indian journal of gastroenterology: official journal of the Indian Society of Gastroenterology*, *19*(2), 53-56.
- Velazhahan, R., Vijayanandraj, S., Vijayasamundeeswari, A., Paranidharan, V., Samiyappan, R., Iwamoto, T., ... & Muthukrishnan, S. (2010). Detoxification of aflatoxins by seed extracts of the medicinal plant, Trachyspermum ammi (L.) Sprague ex Turrill–structural analysis and biological toxicity of degradation product of aflatoxin G1. *Food control*, *21*(5), 719-725.
- Zahin, M., Ahmad, I., & Aqil, F. (2010). Antioxidant and antimutagenic activity of Carum copticum fruit extracts. *Toxicology in vitro*, *24*(4), 1243-1249.
- Zaidi, S. F. H., Yamada, K., Kadowaki, M., Usmanghani, K., & Sugiyama, T. (2009). Bactericidal activity of medicinal plants, employed for the treatment of gastrointestinal ailments, against Helicobacter pylori. *Journal of ethnopharmacology*, *121*(2), 286-291.
- Zarshenas, M. M., Moein, M., Samani, S. M., & Petramfar, P. (2014). An overview on ajwain (Trachyspermum ammi) pharmacological effects; modern and traditional. *Journal of natural Remedies*, 98-105.
- Zarshenas, M. M., Samani, S. M., Petramfar, P., & Moein, M. (2014). Analysis of the essential oil components from different Carum copticum L. samples from Iran. *Pharmacognosy research*, *6*(1), 62.
- Zomorodian, K., Moein, M. R., Rahimi, M. J., Pakshir, K., Ghasemi, Y., & Sharbatfar, S. (2011). Possible application and chemical compositions of Carum copticum essential oils against food borne and nosocomial pathogens. *Middle-East Journal of Scientific Research*, *9*(2), 239-245.