

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 (thymine) contains para-cymene, γ -terpinene, α - and β -pinenes, diketene, 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). 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. runs Amygdalus* (badan) are given in curing amenorrhea 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 bronchodilation 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 bronchodilator 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 bronchodilator effect on asthmatic airways compared to the effect of Theophylline at concentrations used.

Ajwain was attributed to have diuretic and antilithiatic 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.

Key Words: bronchodilation; theophylline; atherogenic index; antilithiatic; antihyperlipidemic

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 Pinaceae, 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 (Minima and Toppi, 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; Starshinas *et al.*, 2014).

The non-thymol fraction (Thymine) contains Para-cymene, Gamma-terpinene, Alpha-pinene, Beta-pinene, α -terpinene, Styrene, Delta-3-carene, Beta-phellandrene, 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, Petroselinum acid, resin acids are isolated from fruits of Ajwain (Qureshi and Kumar, 2010). New glycosyl constituents such as 6-hydroxycarvacrol-2-O- β -D-Glucopyranoside and 3,5-Dihydroxytoluene-3-O- β -D-Galactopyranoside 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 Analgesia meter Device (Dashti-Rahmat Abadi *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 (Hejazi *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 (Hejazi *et al.*, 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 (Petr amfAR *et al.*, 2013). To assay the antibacterial efficacy of Ajwain, acetone and aqueous extracts were tested against *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella typhi- curium*, *Shigella flexneri*, and *Staphylococcus aureus* using 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*

poilus; 7–9 mm against *Escherichia coli*, *Klebsiella pneumoniae* as well as *Bordetella bronchiectasis*. 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 *Clonorchis chinensis* (Chaubey, 2008; Chossudovsky *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). Anthelmintic activity of Ajwain was carried out by considering the *Haemanthus contorts* in sheep and *Ascaris lumbricoides* 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 nematocidal activity. A survey was done on the total essential oil components of Ajwain that showed significant nematocidal activity against pinewood nematode, *Bursaphelenchus xylophilus*. Nematocidal activity of Ajwain essential oils LC50 values 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 (Bozcaada and Shaikh, 2000). Relative studies showed the inhibitory effect of both Ajwain extract and essential oil on Histamine (H1) receptors of isolated guinea-pig tracheal chains (Bozcaada and Shaikh, 2000). In another study, in the field of respiratory, bronchodilator effects of different fractions of Ajwain essential were examined. Results showed that the relaxant and bronchodilator effect of essential oil fractions may be due to the amount of Carvacrol (Bozcaada *et al.*, 2003).

The bronchodilator 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 bronchodilator effect on asthmatic airways compared to the effect of Theophylline at concentrations used (Bozcaada *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 calcium-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 (Elishama *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 (Anila Kumar *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 CCl₄-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 anthia-pretensive 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 Pinaceae plants family and its seeds are used extensively as a food additive in India and mainly therapeutically effective, with hot nature. *C. capsicum* 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. capsicum* have been described and in Persian traditional medicine it is used for thousands of years. The bronchodilator, antitussive, and ant dyspnea effects were demonstrated for *C. capsicum*. 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 (Starshinas *et al.*, 2013).

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

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

The constituents of the seed of *C. capsicum* 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. capsicum* grows indifferent areas of the world containing different compounds. Main components of the oil of Iranian and African *C. capsicum* 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. capsicum* but ethylene methacrylate (6.9%), β -pinene (1.9%), and hexadecane (1.1%) were the other constituents of the plant (Mahboubi and Kazem pour, 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 contains γ -terpinene (48.07%), p-cymene (33.73%), and thymol (17.41%) compared to the composition of plant in Eghlid area which included γ -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). Hydro distillation and supercritical fluid (CO₂) extraction (SFE) methods of the plant were also performed. In hydro distilled oil, there were 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).

Trachipterus 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, antispasmodic 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, Cremo carp 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 no thymol fraction (thymine) contains para-cymene, γ -terpinene, α - and β -pinenes, diketene, 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). (Mahalakshmi *et al.*, 2000)

The principal oil constituents of T. admire carvone (46%), limonene (38%), and dillapiole (9%). (Ishikawa *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, (Banjar, 2004) hypolipidemic, digestive stimulant, (Vasudevan *et al.*, 2000) antihypertensive, hepatoprotective, antispasmodic, broncho-dilating, (Gilani *et al.*, 2003)

antilithiasis, diuretic, abortifacient, galactogogic, antiplatelet-aggregatory, anti-inflammatory, (ThangamandDhananjayan,2003) antitussive (Bozcaada *et al.*, 2003)

antifilarial, (Mathew*etal.*,2008) gastroprotective, (Ramaswamy*etal.*,2008) nematocidal, anthelmintic, (Priestley *et al.*, 2003) detoxification of aflatoxins, (Elishama *et al.*, 2010) and ameliorative effects. (Anila Kumar *et al.*, 2009) Therapeutic uses of T. Ammi fruits include; stomachic, carminative and expectorant, antiseptic and amoebiasis, antimicrobial. Seeds soaked in lemon juice with P runs Amygdalus(badan) are given in curing amenorrhoea and it is also used as antipyretic, febrifugal and in the treatment of typhoid fever. [42]

The antihypertensive effect of T. Ammi administered intravenously in vivo, and the antispasmodic and broncho-dilating 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. (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 CCl₄-induced prolongation of pentobarbital sleeping time in mice, and it tended to normalize the high serum levels of liver enzymes caused by CCl₄-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) anti-inflammatory 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). (Bozcaada *et al.*, 2003) In vitro activity of the methanolic extract of the fruits of Trachipterus Ammi (Pinaceae) against Seteria 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 ant filarial activity against the human filarial worm B. Malaya in Mestomes couch showed macrofilaricidal activity and female worm sterility in vivo against B. Malaya. 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. Malaya parasite in a Mestomes couch 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) Trachipterus 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. (Elishama *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. (Anila Kumar *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 4th generation herbal antibiotic formulation. (Khanuja, 2004)

Phenolic compounds, such as thymol and caracol, are known to be either bactericidal or bacteriostatic agents depending on the concentration used. (Caccini *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 methanolic 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 xenophiles*. Nematicidal activity of ajwain oil constituents (camphene, pinene, myrcene, limonene, terpinene, terpinen- 4-ol, thymol and carvacrol) is against PWN. Hydrochloride and morantal ttrate. (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 nematocidal activity of ajwain oil is mainly attributed to the activity of thymol and carvacrol. Nematocidal 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 *Haemaphys contorts* in sheep. (Kwon *et al.*, 2007) Anthelmintic activity of *T. Ammi* exerts (Chossudovsky *et al.*, 2002) The plant has also been reported to possess cholinergic activity with peristaltic movements of the gut, thus helping in expulsion of intestinal parasail contributory factor to its anthelmintic activity. (Tamura and Iwamoto, 2004; Jabbar *et al.*, 2006)

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