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Ramchander
 OPJS University, Churu,
 Rajasthan, India

Pawan Jalwal
 OPJS University, Churu,
 Rajasthan, India

Anil Middha
 OPJS University, Churu,
 Rajasthan, India

Recent advances on ajowan and its essential constituents

Ramchander, Pawan Jalwal and Anil Middha

Abstract

The ajowan herb is cultivated in many region of the world and is native of Egypt and growing in India, Iran, Iraq, Afghanistan and Pakistan. In India it is cultivated in Madhya Pradesh, Uttar Pradesh, Gujrat, Rajasthan, West Bangol, bihar, Maharashtra. It is identified in different region of the world with different name. *Trachyspermum ammi* (L) sprague fruits or seeds are commonly called as ajowan belongs to the family 'Apiaceae'. Ajowan is much valued for its antispasmodic, stimulant, tonic and carminative. It is given in flatulence, atonic dyspepsia and diarrhea and often recommended for cholera. The studies reveal the presence of various phyto chemical constituents, like volatile oil, protein, fat, Carbohydrate, glycosides, fiber, minerals, saponins, phenolic compounds. Medicinally it has been prove to possess various pharmacological properties like antioxidant, antibacterial, antifungal, hypolipidaemic, antihypertensive, antispasmodic, broncho-dilating, diuretic, antitussive, anthelmintic, abortifient. This review deals with the evidence-based information regarding the Pharmacognostic, Phytochemistry and pharmacological studies of ajowan; hence it is encouraging to find its new therapeutic uses and it can be a good candidate for to be applied in clinical practice.

Keywords: Trachyspermum ammi, Phytochemistry, Ajowan, Essential oil, Thymol, Apiaceae, traditional uses

1. Introduction

The medicinal plant are being used therapeutically all around the world in the treatment of disease. Almost all modern medicines are derived directly or indirectly from medicinal plants. *Trachyspermum ammi* Linn. Sprague, fruits family- Apiaceae commonly known as ajowan in Indian language and Bishop's weed (English name) is an annual herbaceous plant having grayish brown fruits or seeds. It is an erect, aromatic, glabrous or minutely pubescent, branched annual with striate stem, white flowers, up to 90 cm height and the plant is native of Egypt and is cultivated in India, Iran, Pakistan, Afghanistan and Iraq. In India it is cultivated in Utter Pradesh, Gujarat, Rajasthan, Maharashtra, Madhya Pradesh, Bihar and West Bengal. The flower and the fruit are bearing on the plants in the month from January to April. It's fruits or seeds contain 2% to 4% brown color essential oil known as ajowan oil, with thymol as the main constituent (35% to 60%) which is a strong germicide, antispasmodic, antifungal, antimicrobial and also used in perfumery and toothpaste industry. used gastrointestinal ailments, bronchitis, appetite. The ajowan is used traditionally as stimulant, carminative, flatulence, diarrhea, abdominal pain, atonic dyspepsia, piles.

Synonyms (Vernacular Name)

S. No.	Language	Synonyms	S. No.	Language	Synonyms
1.	Hindi	<i>Ajwain, Jevain</i>	7.	Marathi	<i>Onva</i>
2.	Sanskrit	<i>Yamini, Yaminiiki, Dipyaka, Yaviniki</i>	8.	Bengali-	<i>Yauvan, Yavan, Javan, Yamani, Yoyana</i>
3.	Punjabi	<i>Lodhar</i>	9.	Gujarti	<i>Ajama, Ajmo, Javain, Yavan</i>
4.	English	<i>Bishop's seed</i>	10.	Kashmiri	<i>Kath</i>
5.	Tamil	<i>Omem</i>	11.	Telugu	<i>Vamu</i>
6.	Malayalam	<i>Omem</i>	12.	Oriya	<i>Juani</i>

Correspondence
Ramchander
 OPJS University, Churu,
 Rajasthan, India

Classification (Taxonomical)

S. No	Scientific Classification	
1	Kingdom	<i>Plantae- Plant</i>
2	Subkingdom	<i>Tracheobionta</i>
3	Super-division	<i>Spermatophyta- Seed Plants</i>
4	Division	<i>Mangnoliophyta- Flowering plants</i>
5	Class	<i>Mangnoliopsida – Dicotyledons</i>
6	Order	<i>Apiales</i>
7	Family	<i>Apiaceae</i>
8	Genus	<i>Trachyspermum</i>
9	Species	<i>Ammi</i>

Macroscopic description

Ajowan is an erect, glabrous or minutely pubescent, branched spice herb which reaches up to 90 cm in height. Stem is straight, much branched and usually puberulous and striate. The leaves rather distant, 2-3 pinnately divided and forms feather-like tender leaves which are petiolate. Segment of leaves are linear and ultimate which is 1.0-2.5 cm long. Flowers are terminal or seemingly-lateral pedunculate, compound umbels, white, small, pedicels (0.5-4mm) and unequal. Calyx teeth are conspicuous, minute, ovate or obsolete. Petals 1.3x 1.3 mm; fruits 1.2-2 X 1.2-1.8 mm, densely covered in whitish minute papillae, the fruits are oval-oblong, compressed, about 2mm long and 1.7mm wide 5ridges and six vittae in each mericarp, usually separate, 5 primary ridges greenish brown to yellowish brown in colour. They have an aromatic characteristic odour and the taste is sweet aromatic.



Fig 1: Flowering tops



Fig 2: Seeds or fruits

Cultivation and harvesting of ajowan

The plant grows well in India and is largely cultivated in eastern India in the month of October and November as a rabbi crop and seeds are sown directly in the field by broadcasting method. The plant give ripened fruit in late of may The crop can be grown on wide variety of soil from heavy clay to elite loams and is very sensitive to water logging and need good drainage. The plant is tolerant to drought. Harvesting should be done in the month of February and March. In the commercial scale the production of fruits or seeds is about 300 to 350 kg per hectare are to be obtained.

Chemical constituents

Ajowan seed contain tannin, glycosides, carbohydrates (38.6%), protein (15.4%), Fat (18.1%), fiber (11.9%), (8.9%) moisture, saponins, flavones and mineral (7.1%) having iron, calcium nicotinic acid and phosphorus. Seed contain the phenolic glucoside 2-methyl-3- glucosyloxy-5-isopropylphenole, the seeds or fruits yielded 2 to 4.4% brownish essential oil, with thymol is the major component; other include alpha and beta-pinene, camphene, myrcene, and

Microscopic description

The transverse section of fruit shows two hexagonal structures attached with each other by carpophores, epicarps consists of a single layer of tangentially elongated tabular cells, mesocarp consists of moderately thick-walled, rectangular to polygonal tangentially elongated cells having some vittae, carpophores and vascular bundles present as groups of thick-walled radially elongated cells, integument, barrel shaped of tangentially elongated cells, endosperm consists of thin walled cells filled with embryo, oil globules, small and circular, composed of polygonal thin walled cells. The powder microscopy shows the presence of oil globules and groups of endosperm cells.

Adulteration

The ajowan seed is used or available both as whole and in ground form. It is adulterated by addition of exhausted seed (seed from oil or oleoresin has been extract out) excess stem, dust or earth and chaff. The oil of ajowan is also adulterated with ajowan chaff oil, if the chaff oil is added, then thymol oil will reduce to below 35%. The oleoresin may be adulterated by adding synthetic saturated acid. The adulteration can be detected by Gas Chromatography or by thin layer chromatography coupled with HPLC. The seeds are sometime adulterated with *Ban ajowan* or randhuni, *Apium graveolens* (Linn) Sprague.

Flowering top and seeds or fruits of *Trachyspermum ammi*

delta-3-careen, limonene, gamma-terpinene, p-cymene and carvacrol, styrene, alpha-3-carene, beta- phyllanderene, gamma- terpinene, sabinene. The fruit of ajowan contains various minerals copper, lithium, iron, calcium, aluminium, cadmium. It also afforded thiamine, carotene, chromium, cobalt, copper, iodine, manganese, zinc and phosphorus.

Two new compounds 6-hydroxycarvacrol 2-O- β- D- glucopyranoside & 3, 5- dihydroxytoluene 3-O- β- D- galactopyranoside have been reported as glycosyl constituents. From the fruits one more compound named 6-O- β- glucopyranosyloxythymol have been isolated.

Aaromatic compound glucoside $C_{15}H_{22}O_8$ was characterized as 3,4-dihydroxyphenylpropanol-3-O- β- D- glucopyranoside. Nucleosides were identified as adenosine and uridine and glucides were identified as (2S, 3R)-2 methylbutane- 1, 2, 3, 4-tetrol 12) and (3R)-2- hydroxylmethylbutane- 1, 2,3,4-tetrol respectively.

Two new glucosides were identified as 1- deoxy- L- erythritol and 1- deoxypentitol.

The 25 new compound including five new monoterpenoid glycosides, a new monoterpenoid, two new aromatic

compound glucosides and two new glucides, were obtained from the water-soluble portion of the methanol extract of the fruit of ajowan. Their structures were identified by spectral investigation.

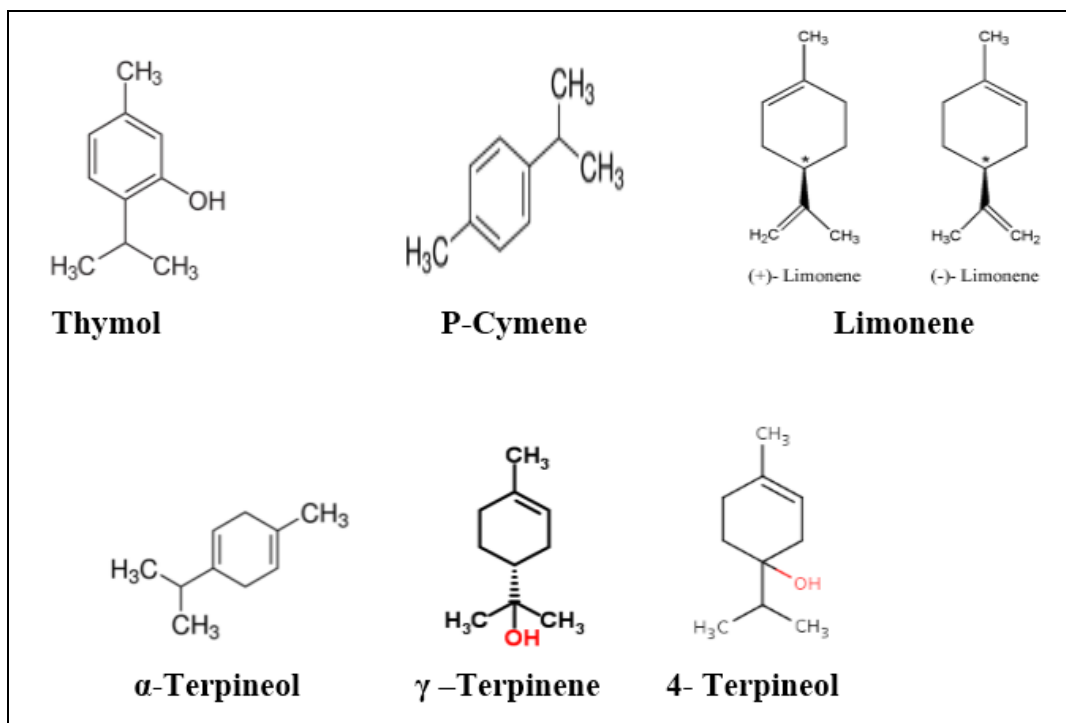
Ajowan Oil

In Ajowan oil thymol is as the main active constituent valued for its antispasmodic, stimulant, tonic and carminative properties. The essential oil obtained by steam distillation of the fruits is known as Ajowan oil. It is used in medicine and is official in Indian Pharmacopoeia. The oil for a long time was the principle source of thymol. Ajowan oil is a colourless or brownish yellow liquid possessing a characteristic odour of thymol and a sharp burning taste.

Ajowan Oil Analysis Data

S. No.	Parameters	Limits
1.	Descriptions	
	Color	Brownish Yellow
	Odor	Characteristic
	Taste	Burning
2.	Thymol content(%w/w)	35-50
3.	Microbiological assay	
	Total bacterial count	NMT 2000cfu/ml
	Total yeast / mould count	NMT 100 cfu/ml
	Enterobacteriaceae count	NMT 100 cfu/ml
	Escherichia Coli	Absent /ml
	Salmonella SP.	Absent /ml
	Pseudomonas aEruginosa	Absent /ml
Staphylococcus aureus	Absent /ml	

Structure of chemical constituents



Therapeutic indications

Ajowan is much valued for its antispasmodic, stimulant, tonic and carminative. It is given in flatulence, atonic dyspepsia and diarrhea and often recommended for cholera. In Unani system of medicine it is used as crude drug to enhance or increase the body immunity and is prescribed in amebiasis. It has potent antimicrobial property.

Classical use

Charaka and sushruta prescribed Yavaani for treating indigestion, colic pain, internal obstructions, anaemia, and diarrhea. For piles, buttermilk added with Chitraka (*Plumbago zeylanica*) and Yavaani powder was prescribed. Yavaani Shunthi (*Zingiber officinale*), Paathaa (*Cissampelos pareira*), pomegranate juice, jaggery, mixed with salt and buttermilk, formed the carminative mixture of Charaka. For treating alcoholism, a decoction of Yavaani was prescribed for its pungent yet pleasant flavour and stimulation warmth for neutralizing the urge for alcohol.

Yavaani and jaggery was prescribed for urticaria (*Vrindamaadhava*). Naarayana Churna (*Shaarangadhara Samhita*), prescribed for chronic constipation, contains both

Yavaani and Ajmodaa (*Trachyspermum roxburghianum*).

Among over the counter drugs of Unani medicine, Majoon-e-Naankhwaah (*Bayaz-e- kabir*) is prescribed in flatulence and anorexia; Araq-e- Ajawaayin as a carminative. Araq Ajeeb contains sub-limited Ajawaayin and pudinaa (*Mentha arvensis*). It is prescribed for dyspepsia, nausea, vomiting, diarrhoea, cholera.

In folk medicine, Ajawaayin is used in conjunction with asafoetida, myrbalans and rock salt or black salt. Taken with buttermilk Ajawaayin is common remedy for relieving difficult expectoration due to dried up phlegm? Ajawaayin-kaa- Phool (Flower of Ajowan crystallized thymol from oil) is administered as an antiseptic and aromatic carminative.

Pharmacological action

Uses in food

Ajowan has characteristic aromatic smell and pungent taste widely used as spices in curries and soups either alone or in combination with other ingredients. Various types of biscuits, beverages, pan mixture pickles are making from ajowan.

Uses in perfume and flavor

Its seeds are used for flavoring of numerous foods, as preservatives in medicines and also used in perfumery and for fragrance purpose in cosmetics. Its essential oil (Thymol) is used by food industries to prevent the growth of mold and bacteria.

Anthelmintic activity

Juice of ajowan leaves are antihelminthic in nature and use as natural helminth infestations in animals.

Diuretic activity

The root of ajowan plant is used as carminative, diuretic, febrifuge and also useful in stomach troubles. Thymol as major constituents of essential oil is widely used against many types of microorganisms. Due to its bactericidal activity against oral bacteria it is normally incorporated in mouth washes.

Pharmaceutical importance of ajowan

The medicinal uses of ajowan can't be ignored. It is used in various GIT disorders, ajowan oil has anti-lithiatic properties due to oestrogenic content that are conventionally used to increase milk yield in dairy farm animals. The essential oil in ajowan has reported the antihyperlipidemic activity in albino rat due to the removal or catabolism of the lipoprotein, inhibition of the HMG-CoA -reductase and or hang-up of lysosomal lipid hydrolytic enzymes created by the liver.

Pharmacological studies of the oil indicated that it had a parasympathomimetic effect and produced contraction of isolated ileum, tracheal chain and bronchial musculature of guinea pig. It also depressed the cardiac musculature in frogs and caused a marked fall in blood pressure in cat. Due to its low toxicity, further trails of the oil as hypotensive agent is recommended. Ajowan is much valued for its antispasmodic, stimulant, tonic and carminative properties. It is administered in flatulence, atonic dyspepsia and diarrhea, and often recommended for cholera. It is used most frequently in conjunction with asfoetida, myrobalans and rocksalt. Ajowan is also effective in relaxed sore throat and in bronchitis, and often constitutes an ingredient of cough mixture. Taken with buttermilk, it is a common remedy for relieving difficult expectoration due to dried up phlegm. Externally, a paste of the crushed fruit is applied for relieving colic pains, and a hot and dry for asthma. Ajowan is also used in the preparation of lotion and ointments, applied for checking chronic discharge. It has been shown to possess antibiotic activity against salmonella typhus, micrococcus pyogenes var. aureus and Escherichia coli.

Dose

3 – 6 gm of drug in powder form.

Antimicrobial activity

The essential oils demonstrated in vitro activity against gram-positive and gram-negative bacteria as well as against yeast. The inhibitory effects of extract on hepatitis C viral (HCV) has been reported and an aqueous extract of ajowan seed have potential activity against Helicobacter pylori, even against metronidazole and tinidazole- resistant isolate. The thymol and carvacrol were reported as active principle for antimicrobial activity in essential oils of ajowan seeds. Phenolic compound are known for bactericidal or bacteriostatic agents depending upon the concentration used.

Ophthalmic uses

Ajowan was effective in acute conjunctivitis and dacryocystitis, as in post cataract surgery and conjunctival xerosi.

Analgesic effects

To evaluate the analgesic effects of ajowan seed, an *in vivo* study was carried out using tail flick Analgesiometer apparatus. The *ethanolic extract* of the plant significantly increase in Tail flick Latency (TFL) during 2 hours post drug administration.

Anti-inflammatory effects

The ajowan fruits have observed anti-inflammatory potentials against rat models (Carageenan induced rat paw oedema) and sub acute rat model (Cotton pellet induced granuloma) they used aspirin 150mg/Kg and Phenyl butazone 150mg/Kg as control. In the acute model, Aspirin and Phenyl Butazone (PBZ) showed an inhibition of 45.23% and 43.83% respectively.

Antibacterial activity

To evaluate the antibacterial activity of ajowan aqueous and acetone extract were tested against *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Salmonella typhimurium*, and *shigella flexneri* by using agar diffusion assay. The study showed that acetone extract show more activity compared to aqueous extract.

Also methanolic extract of T. ammi tested against 11 bacterial species *Pseudomonas aeruginosa* and *Basillus pumilus*; *Staphylococcus aureus* and *staphylococcus epidermidis*; *E. coli*, *Klebsiella pneumonia* and *bordetella bronchiseptica* at 2mg/well in agar well diffusion method showed significant antibacterial activity.

Antifungal activity

The essential oil extracted from the seeds of *Trachyspermum ammi* showed fungicidal effects on *Aspergillus niger* and *Curvularia ovoides* at 5000ppm as minimum inhibitory concentration.

Insecticidal assessments

The essential oil extracted from the seeds of ajowan exhibited insecticidal activity due to their oviposition, egg hatching and developmental inhibitory activities against pulse beetle, *Callosobruchus chinensi*, *Tribolium castaneum*. The essential oil inhibits different stages like larvae to pupae and pupae to adults.

Antioxidant activity

The seeds of ajowan exhibited antioxidant activity by using ABTS and DPPH assay methods, ferric reducing antioxidant power and total phenolic content. The ethanolic extract of T. ammi shows activity against hexachloro cyclohexane (HCH) induced lipid peroxidation.

Hepato-protective Activity

The hepato-protective activity *in vivo* showed that *trachyspermum ammi* was 80% protective in mice against after given a normally-lethal dose of paracetamol, it prevented the CCl₄ induced prolongation of pentobarbital sleeping time in mice and it tended to normalize the high serum level of liver enzymes caused by CCl₄ induced liver damage in rats.

Detoxification of aflatoxins

The seeds extract of *trachyspermum ammi* reflect the maximum degradation of aflatoxin G1 (AFG1). The aflatoxin detoxifying activity was reduced on boiling the fruits or seeds. It is also observed that significant level of degradation of other aflatoxin viz., AFB1, AFB2 by dialyzed seeds extract. Time course study of AFG1 detoxification by dialyzed *T. ammi* extract showed that more than 91% degradation occurred at 24 hours and 78% degradation occurred within 6 hours after incubation.

Gastro protective activity

Due to its digestive stimulant activity of *T. ammi*, a significant shorting of food transit time occurs. *Helicobacter pylori* cause pathogenesis of gastric and peptic ulcer. The ethanolic extract of the plants exhibited antibacterial effect against various strain of *Helicobacter pylori*.

Anti-platelet activity

The ethereal extract of *Trachyspermum ammi* inhibits platelet aggregation induced by arachidonic acid, epinephrine and collagen.

Antihistaminic activity

The essential oil, ethanolic, aqueous and macerated extract of *Trachyspermum ammi* were studied on guinea pig tracheal chains. The results showed clear rightward shift in histamine response curves which indicated a competitive antagonism effect of *T. ammi* at histamine H₁ receptors.

Antihypertensive and antispasmodic activity

The antihypertensive activity of *trachyspermum ammi* administered intravenously *in vivo* and the broncho-dilating activity and antispasmodic action *in vitro* have been evaluated. The aqueous methanolic extract of the seed caused a dose dependent decrease in arterial blood pressure in the animal model. Furthermore, inhibitory effect on the K⁺ - induced contractions was seen in isolated rabbit aorta and jejunum preparations during the application of *Trachyspermum ammi* extract. This resulting proves the potential antihypertensive and antispasmodic activity of *T. ammi*.

Antiviral effects

For the evaluation of antiviral activity of *T. ammi* a methanolic extract was used for *in vitro* assay, which shows a significant inhibitory effect on hepatitis C Virus (HCV) protease.

Spermicidal effects

The spermicidal activities of *Trachyspermum ammi*. essential oil was evaluated via an *in vitro* study where it was revealed that the volatile oil have potent spermicidal activity. Therefore, the oil of *Trachyspermum ammi*. may be considered as natural contraceptive agents.

Abortifacient and galactogogic action

There is a high risk of potential human foetus toxicity of ajowan, based on teratogenicity find in rat fetuses. It has been traditionally used as a galactogogue in humans. The total phytoestrogen content of dry ajowan seed or fruits was 473ppm, which was the second highest in the list of eight herbs tested.

Enzyme stimulant activity

Lactic dehydrogenase, succinic dehydrogenase and cyto oxidase, acetyl colinestrase activity in the nerous tissue of snail altered by *in vivo* contact with *Lymnaea acuminata* to thymol and proven active molluscicidal. The *trachyspermum ammi* also have significant protease activity and also increase the activity of pancreatic lipase and amylase, which may help in digestive stimulant activity.

Nematicidal activity

Pinewilt disease caused by the pinewood nematode (PWN) *Bursaphelenchus xylophilus*. The *trachyspermum ammi* shows nematicidal activity against Pinewood nematode. PWN bodies are treated with the muscle activity blockers levamisole hydrochloride and morantal tartrate. Hydroxyl and amino groups have been hypothesized as target sites of methyl isothiocynate in nematodes. Thymol and carvacrol were very much effective against PWN. The nematicidal activity of ajowan essential oils LC₅₀ values was 0.431mg/ml.

Ameliorative activity

The extract of *Trachyspermum ammi* effects on hexachlorocyclohexane (HCH) induced oxidative stress and toxicity in rats was investigated. Pre feeding of its 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 may be decreased by the dietary *T. ammi* extract.

Ajowan safety & Interaction

Ajowan is generally regarded as safe when taken in the recommended doses; however, it can cause skin irritation in some people. If your skin becomes irritated with use of Ajowan, discontinue using it and the symptoms will subside. Its ability to inhibit platelet aggregation caution is warranted in pregnancy or in those taking drugs such as warfarin or nonsteroidal anti-inflammatory. The thymol has been considered safe by the European commission and the US-FDA as flavoring agent.

Side effect of ajowan

The following possible side effects may be occurs in drugs having *Trachyspermum ammi*. These side effects are possible, but do not always occur.

- Acidity
- Burning Sensation
- Mouth ulcer

Toxicology

Ajowan is toxic in high doses and can result in fatal poisoning. The essential oil isolated from Ajowan seeds showed cytotoxic activity against P388 mouse leukemia cells.

Storage

Seeds are stored in protected from light in well filled containers, at a temperature not exceeding 30 °C.

Conclusion

Trachyspermum ammi is an important medicinal plant which has both medicinal as well as nutritive value and has a great potential for further studies, because of its major use by the local herbalist. The plants have wide established and hidden therapeutic values. So the plants need a scientific exposure to

the hidden curative and therapeutic potential.

References

1. The Ayurvedic Pharmacopoeia of India, Government of India, Ministry of Health and Family welfare, department of Ayush; 01(01):170-171.
2. Anonymous. The wealth of india, A Dictionary of Indian Raw Materials and Industrial Products Publications and information directorate. New Delhi CSIR; 2003; 10: 267-272.
3. Chatterjee A, Chanderprakash S, The Treatise of Indian Medicinal Plants. Publication and information Directorate CSIR, New Delhi; 1995; 4:45-47.
4. Singh I, Singh VP. Antifungal Properties of aqueous and organic extract of seed plants against *Aspergillus flavus* and *A. niger*. *Phytomorphology* 2000; 20:151-157
5. Sivropoulou A, Papanikolaou E, Nilolaou C, Kokkini S, Lanaras T, Arsenaki M. antimicrobial and cytotoxic activities of *Origanum* essential oils. *J agric Food Chem*. 1996; 44:1202-1205.
6. Katasani D, Srinu B, Bala R. Phytochemical screening, quantitative estimation of total Phenolic, Flavonoids and antimicrobial evaluation of *Trachyspermum ammi*. *J of atoms and Molecules* 2011; 1(1):1-8.
7. Pruthi JS. Spices and condiments, 4th ed. Delhi (India): National book Trust Publisher. 1992.
8. Ishikawah T, Sega Y, Kitajima J. water- soluble constituents of *Ajowan*, *Chem Pharm Bull* 2001; 49:840-844.
9. Chopra RN. Chopra's Indigenous Drugs of India, 2nd edition Calcutta (India); Academic Publishers, 1982.
10. Garg S. A new glucoside from *Trachyspermum ammi* *Fitoterapia*. 1998; 6:511-512.
11. Nagalakshmi S, Studies on chemical and technological aspect of *Ajowan* (*Trachyspermum -ammi*) *Journal food Sci Technol*. 2000; 37:277-281.
12. Asima, Chatterjee, Satyesh Chandraprakash. The Treatise of Indian Medicinal Plants. Publication and Information Directorate CSIR: New Delhi, 1995; 4:45-47.
13. Krishnamoorthy V, Madalageri MB. Bishop weeds (*Trachyspermum ammi*): an essential crop for north Karnataka. *J. Med and aromatic Plants Sciences*. 1999; 21(4):996-998.
14. Boskabady HM, Jandaghi P, Kiani S, Hasanzadeh L. Antitussive effect of *Carum copticum* in Guinea Pigs. *J Ethnopharmacol*. 2005; 97:79-82.
15. Gilani AH, Jabeen Q, Ghayur MN, Janbaz KH, Akhtar MS. Studies on the antihypertensive, antispasmodic, bronchodilator and hepatoprotective activities of *Carum*.
16. She M, Mark FW. *Trachyspermum* Link, *Enum Hort Berol Alt*. 1: 267. 1821, nom. Cons." *Flora of China*. 2005; 14:77-78.
17. Kwon Park I, Junheon K, Sang-Gil L. Nematicidal Activity of Plant Essential oils and Components from *Ajwain*, *Allspice* and *Litsea* oils against Pine wood Nematode. *Journal of Nematology*. 2007; 39(3):275-279.
18. Kostyukovsky M, Rafali A, Gileadi C, Demchenko N, Shaaya E. Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: possible mode of action against insect pests. *Pest Manag Sci*. 2002; 58(11):1101-06.
19. Tamurab T, Iwamoto H. Thymol – a classical small molecules compound that has a dual effect on myosin biochemical and biophysics *Research Communications* 2004; 18:786-789.
20. Jabbar A, Iqbal Z, Khan MN. In Vitro anthelmintic activity of *Trachyspermum ammi* seeds. *Pharmacognosy Magazine*. 2006; 2:126-129.
21. Sabar AG. Lithotripsy of different urinary tract stones by using seeds of *Carum copticum*. *Iraqi Journal of Pharmaceutical Sciences*. 2010; 62(1):23-29.
22. The Quality standards of Indian Medicinal Plants antimicrobial screening of some Indian spices. *Phytotherapy Research*. 2005; 13:616-618.
23. Sexena AP, Vyas KM. Antimicrobial activity of seeds of some ethnomedicinal plants. *Journal of Economic and Taxonomic Botany* 1986; 08(2):291-300.
24. Khanuja SPS. Formulation Comprising Thymol useful in the treatment of Drug Resistance Bacterial infection, CSIR, New Delhi United State Patent, 2004, 6824795(2);
25. Singh DB, Singh SP, Gupta RC. Anti-fungal effect of volatiles from seeds of some *Umbelliferae*. *Transactions of the British Mycological Society* 1979; 73(2):349-350.
26. Caccioni DR, Guizzardi M, Biondi DM. Relationship between volatile components of citrus fruit essential oil and antimicrobial action of *Penicillium digitatum* and *Penicillium italicum*. *International Journal of Food Microbiol*. 2000; 88:170-175.
27. Biswas NR, Gupta SK, Dass GK. Evaluation of ophthalmic eye drops- a – herbal formulation in the management of various ophthalmic disorders. *Phytotherapy Research*. 2000; 15:618-620.
28. Dashti- Rahmatabadi MH, Hejazian SH, Morshedi A, Rafati A. The analgesic effect of *Carum copticum* extract and morphine on phasic pain in mice. *J Ethnopharmacol*. 2007; 109:226-228.
29. Thangam C, Dhananjayan R. Antiinflammatory potential of the seeds of *Carum copticum* linn. *Indian J. Pharmacol.*, 2003; 35:388-391.
30. Kaur GJ, Arora DS. In vitro antibacterial activity of three plants belonging to the family *Umbelliferae*. *Int Journal of antimicrob Agents*. 2008; 31(4):393-395.
31. Zaidi SFH, Yamad K, Kadowaki M, Khan U, Sugiyama M. Bactericidal Activity of Medicinal Plants, Employed for the treatment for Gastrointestinal Ailments, Against *Helicobacter pylori*. *J Ethanopharmacol*. 2009; 121:286-291.
32. Shahidi B. Evaluation of antibacterial properties of some medicinal plants used in Iran. *J Ethanopharmacol*. 2004; 94:301-305.
33. Dwivedi SK, Singh KP. Fungi toxicity of some higher plant products against *Macrophomina phaseolina* (Tassi) Gold Flavour and fragrance *J* 1998; 13(6):397.
34. Singh VK, Govil JN, Arunchalam C. Recent Progress in Medicinal Plants. *Houston Texas (USA)*; 2007, 17.
35. Rajan B, Manmohan S, Singh SR, Singh RB. Medicinal uses of *Trachyspermum ammi*: A Review. *The Pharma Research*. 2011; 5(2):247-258
36. Gurinder JK, Daljit SA. In vitro antibacterial activity of three plants belonging to the family *Umbelliferae*. *Intl J antimicrob agent*. 2008; 31:380-399.
37. Mathew N, Misra-Bhattacharya S, Perumal V, Muthuswamy K. Antifilarial Lead molecules Isolated from *Trachyspermum ammi*. *Molecules*. 2008; 13:2156-2168.
38. Duby N. cytotoxic activity of the essential oil of *Trachyspermum ammi* and *Eupatorium cannabinum*, *India drugs*. 1997; 34:471-472
39. Srivastava KC. Extract of spice-omum (*Trachyspermum*

- ammi shows antiaggregatory effects and alters archidonic acid metabolism in human platelets prostaglandins lieukot and essential fatty acids. 1988; 33:1-6.
40. Copticum seed extract, Journal of Ethanopharmacology, 2005; 98(12):127-135.
 41. Choubey MK. fumigant toxicity of essential oils from some common spices against pulse bettle, *Callosobruchus chinensis* (Coleoptera: Bruchidae) J Oleo Sci. 2008; 57(3):171-179.
 42. Velazhahan R, Vijayanandraj S, Vijayasamundeeswari A, Paranidharan V, Samiyappan R, Iwamoto T *et al.* Detoxification of aflatoxins by seed extract of medicinal plants *Trachyspermum ammi* (L.) Sprague ex Turrill Structural analysis and biological toxicity of degradation product of aflatoxin GI. Food Control. 2010; 21:791-25.
 43. Singh VK, Singh S, Singh DK. Effect of active Mulluscicidal component of spices on different enzyme activites and biogenic amine levels in the nervous tissue of *Lymnaea acuminata*. Phytother Res. 1999; 13(8):649-54.
 44. Ali S, Qazi AH, Khan MR. Protease activity in seeds commonly used as herbal medicine. Pakistan J Med Res. 2004; 43(2):70-73.
 45. Rao RR, Patel K, Srinivasan K. In vitro influence of spices and spice- active principals on digestive enzymes of rat pancreas and small intestine. Nahrung. 2003; 47(6):408-12.