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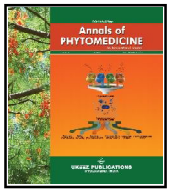

Review Article : Open Access

An insight of *Trachyspermum ammi* L.: A comprehensive review on its aromatic and medicinal potential

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Abstract

Trachyspermum ammi L. is one of the key medicinal plant that has been used in traditional system since centuries. The present review compiled the information of *T. ammi* concerning its ancient medicinal use, botanicals, phytochemical, biologicals and clinical trials. The information tools considered in the manuscript were previous published studies, databases such as Science-Direct, Google scholar, pubmed and some ayurvedic text on *T. ammi* Besides, diverse bioactives of *T. ammi* highlighted the confirmation of some lead constituents and these bioactives are responsible for various biological activities such as antibacterial, analgesic, antidiabetic, antiulcer, antiviral and antioxidant. Pharmacological data and clinical study revealed that *T. ammi* might be a possible plant against the treatment of various diseases. The present review could provide a platform for future investigations of *T. ammi* by linked the traditional claims with pharmacological action along with bioactives of this plant.

1. Introduction

India is recognized as botanical garden of the world and also called as “Land of Spices” globally. The cultivation of spices started in India since centuries. These spices are mainly contributing for adding flavour and aroma to various products (Krishnakumar, 2019). All the spices posses diverse medicinal value and provide health benefits (Soni and Agarwal, 2022; Naik and Pidigam, 2021). *Trachyspermum ammi* L. belongs to the family Apiaceae and extensively harvested in several regions of South Asia (Asif and Hashmi, 2021). *Trachyspermum* derives its name from two Greek words: “*Trachy*”, which means “rough” and “*spermum*”, which is known as “seeded”, while species “*ammi*” is a Latin word (Dwivedi *et al*., 2012). Due to its aromatic smell and spicy flavour, this plant has tremendous therapeutic value and is also used as a spice in Indian foods (Gersbach and Reddy, 2002). The fruits, leaves and seeds of this plant are the most useful portions. In Ayurveda, *T. ammi* decoction is used as a first-line treatment for abdominal discomfort, loose bowels, cough and stomach discomfort (Anilakumar *et al*., 2009).

Bioactives present in the spices prevent against disease development and maintain health (Krishnakumar, 2019). These bioactives directly and indirectly responsible for the wide range of biological activities (Hoque and Taufique, 2019). The plant’s principal active phytochemical constituent is thymol which is as linked with many important therapeutic effects (Anwar *et al*., 2016; Wan *et al*., 2018). Thymol which is present in *T. ammi*, found effective against various therapeutic activities. It has been reported that more than 30% thymol is found in *T. ammi* oil, which is a powerful germicide, antibiotic, fungicide and antispasmodic (Bairwa *et al*., 2012). *T. ammi* is an antioxidant, antirheumatic, carminative, antiflatulent, diuretic, hepatoprotective, antimicrobial, antifungal, antibacterial and other activities contribute to its medicinal and pharmacological potential (Saxena *et al*., 2012; Singh and Meghwal, 2019). *T. ammi*’s strong antioxidant content, primarily polyphenols and flavonoids make it a promising candidate for nutraceutical development (Ranjan *et al*., 2011). As a journey from antiquity to modernity, present work is compilation of *T. ammi* including its information on botany, extraction techniques, bioactives, biological studies and clinical studies.

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2. Geographical distribution

Trachyspermum ammi (L.) is originated to Egypt and very well distributed in Iraq, Iran, Afghanistan, Pakistan and India in arid to semi-arid regions normally soils contain high levels of salts (Akhlaghi *et al*., 2014). *T. ammi* is planted in first week of October and harvested in May month and mostly grown in India. The fruits and seeds are edible and in traditional medicine. Usually used as spice in India, Middle East Asia and some parts of America (Arif, 2019).

3. Botanical description

T. ammi is an erect, striate stem is branched or striated including glabrous or pubescent properties reached up to a height of 90 cm tall. *T. ammi* is an yearly herb and morphology is pinnate, upper leaves are smaller and shortly petiolate and lower leaves have long petioles. 4-12 rays of flower heads are white in color, which is having corolla 5, petals bilobed, stamen 5 and ovary inferior. Fruits are brown in color and are in the form of ovoid. They gradually are 2 mm long and 1.7 mm wide. The *T. ammi* seeds are also recomended for their essential oil (Rohamare *et al*., 2013).

4. Extraction techniques

Various scientists have performed experiments on the extractions of *T. ammi* and reported the yield value of it. *T. ammi* was found 2.2 % yield of essential oil by using Clevenger apparatus (Singh *et al*., 2004). In another study performed by Shabnam Javed (2012), powdered seeds of *T. ammi* were found an yield value of 4% which was performed in Soxhlet apparatus (Shabnam Javed, 2012). While another study demonstrated that ripe fruits of *T. ammi* having a yield value of 2.7% (Vitali *et al.*, 2016) and its oil of seeds by using microwave-assisted extraction (MAE), was found a higher yield (Mazzara *et al*., 2021). Table 1 illustrates the extraction conditions for *T. ammi.*

Table 1: Different extraction conditions of *T. ammi* including yield value

SL. No.	Part used	Method	Temperature and time duration	Solvent	Yield	Instrument	Ref.
1.	Fruits	Hydrodistillation	6 h	Distilled water	2.2%	Clevenger apparatus	Singh *et al.*, 2004
2.	Dried and powdered seeds	Hydrodistillation	3 h	Distilled water	4%	Soxhlet assembly	Shabnam Javed, 2012
3.	Fruits	Hydrodistillation	3 h	Distilled water	2.7%	Clevenger type apparatus	Vitali *et al.*, 2016
4.	Powdered plant material	Hydrodistillation	5 h	Distilled water	1.20%	Clevenger type apparatus	Singh and Ahmad, 2017
5.	Powdered plant material	Solvent extract	24 h	Hexane	1.82%	-	Singh and Ahmad, 2017
6.	Powdered plant material	Ultrasonic assisted extraction	25°C, 30 min	Hexane	2.30%	Ultrasonic assisted equipment	Singh and Ahmad, 2017
7.	Powdered plant material	Super critical-CO_2 extraction	25-40°C, 30 min	-	2.64%	-	Singh and Ahmad, 2017
8.	Seed	Microwave assisted extraction	25 to 250◦C and pressure from 0 to 300 psi	Methanol	3.18%	Microwave assisted extraction apparatus	Gujar *et al.*, 2010

5. Phytochemical analysis

T. ammi has reported for energy value upto 314.55%a and this plant is a good source of carbohydrates, protein and fiber also. From functional sides, *T. ammi* is recommended as key ingredients in food and good source of carbohydrates, proteins and energy. The evidence of bioactives contributes to enhance its nutritive image, and hence confirmed to be important sources of foods and spices (Hafiz, 2012). Chemically, *T. ammi* contains carbohydrates, flavones, glycosides, fibre, saponins and tannins. Thymol, a-and a-pinenes, dipentene, a-terpinene and traces of camphene and myrcene are also observed in this plant. Extracts of *T. ammi* possess saponin. Different analytical tools performed for the quantitative analysis of *T. ammi*. These analysis equipments are most widely used for quick and easy determination of quality authenticity and purity of the *T. ammi.* In a study of this plant, HPTLC fingerprinting revealed the thymol peaks at UV 366 nm in petroleum ether, dichloromethane, chloroform, methanol and ethanol extract generated in a solvent system (toluene: ethylacetate; 93:7). The information gathered from this investigation, could be utilized to establish a quality standards (Chauhan *et al*., 2012). In another study, its oil was analyzed using GC-FID and GC–MS (Vitali *et al*., 2016). Dhaiwal *et al*. (2017) investigated the composition of seed oil using gas chromatography-mass spectrometry (GC-MS) (Dhaiwal *et al*., 2017). The extraction of thymol from *T. ammi* seeds were analyzed by FTIR spectra (Bajpai and Agrawal, 2015). Table 2 illustrates the metabolite profiling of *T. ammi* using various analytical tools.

6. Phytochemical investigation

Various geographical locations affect the bioactives of *T. ammi*. Published literature confirm the evidence of bioactives of *T. ammi* and number of bioactives in *T. ammi* were reported with the help of numerous analytical tools (Naeem Khan *et al*., 2020). Studies revealed that these bioactives are carbohydrates, proteins, crude fat, crude fibre, glycosides, tannins, saponins, and flavones (Zarshenas *et al*., 2013). A study reported that *T. ammi* also contains variety of macro and micronutrients (Qureshi and Kumar, 2010). The gas chromatography/mass spectrometry (GC-MS) confirmed nineteen volatile compounds, which include phenol thymol, p-cymene and carvacrol (Vitali *et al*., 2016). Another study by (Krishnamoorthy and Madalageri, 1999) highlighted the presence of 27 compounds in *T. ammi* seed essential oil through GC-MS analysis, *viz*., thymol was

found one of the lead compound whereas others 20 compunds were confirmed by Jain *et al*. (2018) reported that thymol was discovered to be the most abundant compound, followed by ɡ-terpinene a-thujene and myrcene and other compounds include a-terpinene, terpinen-4-ol and a-terpineol. Moazeni *et al*. (2012) discovered the primary compounds to be thymol, ɡ-terpinene and p-cymene. Abdullah *et al*. (2020) reported a total of nine substances in their study.

Table 2: Suggested protocol conditions for metabolite profiling of *T. ammi* samples

Technique	Specifications	Conditions/Parameters	References
Gas Chromatography-Mass Spectrometry (GC-MS) analysis	Sample preparation	*T. ammi* essential oil was obtained	Dhaiwal *et al*., 2017
	Gas chromatography system column	Oil profiling of chemical composition of *T. ammi*	
	Temperature	The GC oven temperature - maintained at 50°C for 5 min then raised to 250°C at a rate 5°C/min, detector temperature 290°C	
	Sample injection	Helium with a linear velocity of 32cm/s	
	Data analysis	NIST08, WILEY8	
Nuclear Magnetic Resonance (NMR) analysis	Sample preparation	Hydrodistillation method	Dhaiwal *et al*., 2017
	NMR spectrometer specifications for measurements	1H NMR (400 MHz) and 13C NMR (100 MHz) spectra were recorded with a Bruker AC or described as solutions (in CDCl3) with tetramethylsilane (TMS) as an internal reference	
	Chemical shifts during sample analysis	The chemical shifts were measured in parts per million (ppm), with the abbreviations "s," "d," "t," and "m" standing for singlet, doublet, triplet, and multiplet, respectively	
Gas Chromatography-Flame Ionization Detector analysis	Sample preparations	Hydrodistillation	Vitali *et al*., 2016
	Gas Chromatography-Flame Ionization Detector	Ionisation flame detector (FID) was used	
	Temperature	Temperature programme: 5 min at 60 C, subsequently 4°C/min up to 220°C, then 11°C/min up to 280°C, held for 15 min, temperatures -280°C	
	Sample injection	Oil samples diluted in n-hexane to a concentration of 1:100 and injected at a volume of 1 lL	
	Data analysis	HP3398A GC Chemstation software (Hewlett Packard, Rev. A.01.01) was used to collect data	
High Performance Thin Layer Chromatography Fingerprinting	Sample preparation	Extract was concentrated individually under reduced pressure. On TLC plates, sample spots were separated using a toluene: ethyl acetate (93:7) solvent system	Chauhan *et al*., 2012
	Thin Layer Chromatography Fingerprinting	Visualisation techniques, UV radiation at 254 nm, UV 366 nm, iodinesation, and spray reagents	
	High Performance Thin Liquid Chromatography Scanning	For densitometric analysis, Camag HPTLC scanner IV	
High Perfomance Liquid Chromatograpy (HPLC)	Extraction of plant material	*T. ammi* seeds were rinsed and placed in a beaker with 180 ml of distilled water	Somak Chatterjee *et al*., 2017
	Sample preparation	(Triton X-100, SPAN 80 or TWEEN 80) dissolved solvent (Acetonitrile and water mixture (65:35, v/v) were used as mobile phase)	
	High Performance Liquid Chromatography System	Agilent Zorbax C-18 reverse phase HPLC column (4.6 mm I.D; 250 mm length and 5 lm particle size)	
	Standard solution	Standard thymol solutions (10-1000 mg/l) in acetonitrile and filtered through a 0.2 µm syringe filter (whatman)	
	Sample injection	Flow rate of 0.5 ml/min. Injection volume - 30 µl, wavelength-280 nm for thymol	
	Fourier Transform Infrared Spectroscopy (FTIR)	M/s, Perkin Elmer, Fourier Transform Infrared Spectroscopy (FTIR)	

7. Pharmacological activity

7.1 Antifungal activity

An experiment confirmed by Singh *et al.* (2004) and reported that oil from this plant found potential against all of the tested fungi such as *Aspergillus niger*, *Fusarium monoliforme* and *Pencillium madriti* by using the inverted petriplate technique. Similarly in another study, impact of hydroextract of *T. ammi* was performed; *Candida albicans* growth and biofilm was investigated in *vitro* study (Sarfraz *et al*., 2016). Pandey *et al*. (2013), in their study, observed that methanol extracts of *T. ammi* have potent antifungal activity against a variety of fungi (*Aspergillus niger* and *Trichoderma* sp.) whereas Arasu *et al*. (2021), has investigated methanol extract of *T. ammi* seeds against *C. albicans* with a concentration of 27 mm in 250 µl. The alcoholic extracts of *T. ammi* seeds and leaves were found to be more efficient against the test pathogenic fungi than the aqueous extracts in a study (Khan and Jameel, 2018). The reason may be due to the presence of phenolic and its solubility property in polar solvents (Aldred *et al*., 2009). Thymol may be responsible for the antifungal activity and considered as an antifungal agents after detailed research (De Castro *et al*., 2015). Various scientific evidences could lead for antifungal, and health supplement products based on thymol in near future.

7.2 Analgesic and anti-inflammatory

The anti-inflammatory effect recorded by *T. ammi* in different experiments. The anti-inflammatory effect may be due the presence of some bioactives such as flavonoids, terpenes and glycosides. Different analytical tools also supported the presence of these bioactives which can be responsible in the inhibition of prostaglandin synthtase. Experiment performed by various scientists confirmed the evidence of *T. ammi* possesses a analgesic effect. Dashti-Rahmatabadi *et al*. (2007) investigated the analgesic effect of *T. ammi* by using tail-flick analgesiometer device. When alcoholic extract combined with morphine which was found significantly increase tail-flick latency (TFL) 2 h after delivery ($p< 0.05$). In another study conducted by (Al-Khazraji, 2019), ethanolic extract of *T. ammi* was found as a pain reliever. The results revealed that *T. ammi* has an effective against pains (Al-Khazraji, 2019) and there is an need for more reserch on it.

7.3 Antihypertensive activity

The antihypertensive potentail of *T. ammi* studies *in vivo* and the brocho-dilating activity and antispasmodic action *in vitro* (Naeem Khan *et al*., 2020). The aqueous extract of *T. ammi* was performed to validated its antihypertensive potential and during the study was found that *T. ammi* extract causes dose dependent fall in hypertension (Aftab and Usmanghani, 1995). In another study, thymol which is one of the lead of *T. ammi* was studied and research finding support that the due to presence of thymol in *T. ammi*, it may be responsible for the antihypotensive effects after investigated in the *in vivo* studies (Rathod *et al*., 2021).

7.4 Antiviral activity

T. ammi oil was found to effective against Japanese encephalitis virus (Hussein *et al*., 2000). Another study on methanol and water extracts of *T. ammi*, result showed that inhibitory effects against hepatitis C virus protease. In another study, the oil from *T. ammi* has shown considerable antiviral activity. Thus, a novel compound from *T. ammi* could be of interest for further research (Kazemi Oskuee *et al*., 2011).

7.5 Antiepileptic activity

In an experiment, *T. ammi* was found significant antiepileptic activity when compared to control in mice. The study recomended that *T. ammi* extract can significantly delayed convulsions by 6.25 ± 0.51 m when compared to the control group (0.146 ± 0.01 m). *T. ammi* has the potential and act as an antiepileptic effect in some animals study. The presence of thymol in the methanol extract of *T. ammi* may be the reason for an antiepileptic action (Rajput *et al*., 2013).

7.6 Antidiabetic activity

T. ammi demonstrated the antihyperglycemic effect and oil from *T. ammi* also possess significant antidiabetic activity. Oil from *T. ammi* has the ability to block carbohydrate metabolism enzymes (Aneesa *et al*., 2019). Hence, *T. ammi* oil could be included in the current trend of discovering new plants having antidiabetic properties. In another study, diuretic investigations *in vivo of T. ammi* in rats were also studied. The research found that *T. ammi* was not so much effective in urine production also and not effective in kidney stones as per author's experiment.

7.7 Ameliorative effect

Ameliorative potential of *T. ammi* was studied by authors. Anilakumar *et al*. (2009) has mentioned in their study that *T. ammi* extract has reduction in hepatic levels. Moreover, *T. ammi* extract at a concentration of 1% before being injected with HCH, found that toxicity caused by HCH, could be mitigated by dietary *T. ammi* extract (Kulkarni *et al*., 2021).

7.8 Antibacterial activities

T. ammi tested in various experiments and found its ability against diffrent bacterial strains. Vitali *et al*. (2016) suggested that *T. ammi* oil has the ability to inhibit gram-positive bacteria. The reference drug was ciprofloxacin in their study. Murthy *et al*. (2009) revealed that essential oil of *T. ammi* has broad-spectrum antibacterial action against food-borne microorganisms. The presence of terpinene, thymol and carvacrol, indicates that *T. ammi* oil and seed extracts have antimicrobial properties (Sharma *et al*.,2018; Al-Abd *et al*., 2013; Klein *et al*., 2013). Reseach findings suggested that oil from *T. ammi* possess compounds having significant antibacterial properties and these might be considered as an antibacterial agents in near future.

7.9 Antiulcer activity

Ethanolic extract of *T. ammi* (100 mg/kg and 200 mg/kg) was found effective against antiulcer activity. The experiment was done on group of rats and observed by reducing ulcerative lesions when compared to the control group (Ramaswamy *et al*., 2010). Research supports that *T. ammi* has an antiulcer effects could potentially be due to the presence of tannin (Al-Rehaily *et al*., 2002). Another experiment was performed to investigate the ability of *T. ammi* extract on healing ulcers in animals. Experiment findings showed that *T. ammi* is effective to heal ulcer when comparable with omeprazole. Further studies are required to understand the actual mechanisms of action.

7.10 Antioxidant activity

Leaves of *T. ammi* showed stronger antioxidant activity conducted by Raza *et al*. (2015). Literature suggests that the presence of alpha

pinene, thymol and carvacrol can act as an antioxidant activity in *T. ammi*. Studies performed by Ramos *et al.* (2014); Singh *et al.* (2006); Chatterjee *et al.* (2013) reported that *T. ammi* oil has potent antioxidant study. In another study, *T. ammi* was showed maximum inhibition in a nitric oxide radical scavenging activity (Bajpai and Agrawal, 2015). An experiment was performed and it was observed that the extract of *T. ammi* seeds showed antioxidant effects in collagen-induced arthritis rats (Sadiq Umar, 2012). In another study, FRAP value of methanolic and aqueous extracts of *T. ammi* seeds was studied as an antioxidants parameters (Goswami and Chatterjee, 2014). *T. ammi* extracts could provide a large bioresource of antioxidants for use in daily living, as well as in food and nutraceuticals.

7.11 Anthelmintic activity

Research experiments confirmed the anthelmintic activity of this plant. It is investigated that *T. ammi* seeds to determine the ovicidal efficiency, which is commonly used as an anthelmintic for worm management in sheep. In an experiment, *in vitro* ovicidal effect of crude aqueous (CAE) and methanolic extracts (CME), an egg hatch test (EHT) was performed on *Haemonchus contortus* ova and support the anthelmintic characteristics of *T. ammi* (Moraes *et al.*, 2013). Figure 1 explains the mechanism causing this activity.

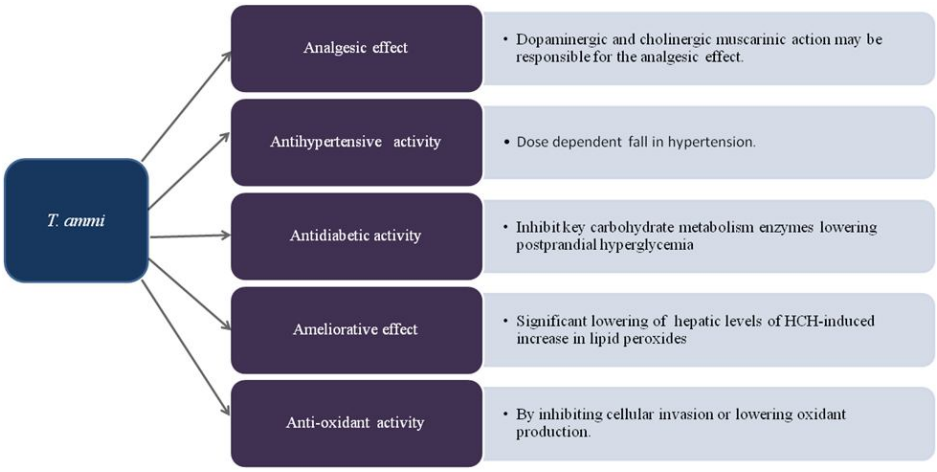

Figure 1: Various pharmacological activities confirm the scientific validation of *T. ammi*.

8. Clinical studies

Various studies have support the safety and efficacy of *T. ammi*. The use of *T. ammi* as mentioned in Ayurveda text and inspired for the clinical use in various ailments. *T. ammi* gel was found effective against acne in a clinical trians study (Talebi *et al.*, 2020). *T. ammi* seed oil helps in curing neuropathy pain in multiple sclerosis patients (Namjooyan *et al.*, 2019).

In a double-blind, clinical study with patients suffering from neuropathic pain, *T. ammi* 10 % topical cream alleviated foot burning, a neuropathic complication (Gaddam *et al.*, 2019). Thymol and carvacrol may be the constituent responsible for relieving pain (Nagoor Meeran *et al.*, 2017). *T. ammi* is considered as safe, but some of effects were reported which can cause nausea and headache. Safety profile in pregnant, kids or with people severe disease is not reported.

9. Conclusion

T. ammi are used traditionally as ayurvedic plants to treat various chronic diseases. The present study highlights the evidence-based information available of *T. ammi* on phytochemicals and pharmacological activities. Besides, *T. ammi* could be a potential source for the treatment of a wide range of disorders along with diverse phytochemicals.

T. ammi market potential is big and available in different formulation such as capsule, powder and essential oil. *T. ammi* can explored further as per its ancient uses and broad range of parmacological active phytochemicals reported earlier in different regions of this plant. In addition, the undocumented information of the target plant has to record and should be explored widely. So, that it could serve as a active lead to treat different aliments and more additional studies are required for data regarding aspects of this plant.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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