RESEARCH PAPER

Phytochemical Constituents and Diverse Pharmacological Activities of Trachyspermum Ammi Linn- A Comprehensive Review

Lalita Kumari[1], Snehlata Yadav[1]*, Neeta Solanki[1], Sanjiv Kumar[1], Sunil Kumar[1], Nirmala Kumari Yadav[1]

[1]*Department of Pharmaceutical Sciences, Indira Gandhi University, Meerpur, Rewari, Haryana-122502, India*
[1*]*Assistant Professor, Department of Pharmaceutical Sciences, Indira Gandhi University, Meerpur, Rewari Haryana-122502, India*
***Corresponding Author:** Dr. Snehlata Yadav*
montygunwal@gmail.com

Received: 24th April, 2026; Revised: 20th May 2026; Accepted: 30th June, 2026; Available Online: 10th July, 2026

ABSTRACT
According to the World Health Organization (WHO), about 80% global population depends on herbal medicine for treatment of diseases. There are different plants that are used to treat different types of disease such as anticancer, antimalarial and antimicrobial, antibacterial, anti-inflammatory, antifungal, immunomodulatory activity. The increased inclination towards the use of herbal drugs is mainly due to their lesser side-effects. Ajwain is one such medicinal plant that has been used since ages by our ancestors for the treatment of various ailments. Its scientific name is Trachyspermum ammi (T. ammi) and it belongs to Apiaceae family of plantae kingdom. T. ammi is an annual herb that is found grown in Bihar, UP, Gujarat, West Bengal, Maharashtra, and Rajasthan. It is generally cultivated in October to November and collected in the month of May to June. Its main active constituents include thymol, β- pinene, γ-terpinene, carvacrol, α-pinene, and p-cymene. Thymol is the main active constituent that are responsible most of the pharmacological activities. Our ancestors used T. ammi water for metabolism boosting, digestive system cleansing, weight management as well as weight loss and for regulating the menstrual cycle in women. The present literature reports various pharmacological activities of T. ammi such as anticancer, antimicrobial, antiviral, antimalarial, antioxidant, immunomodulatory, antifungal, anti-inflammatory, antidiabetic, antiepileptic, antihyperlipidemic, antidermatophytic, antipyretic, antispasmodic and anxiolytic activities in a chronological manner.

Keywords: *Antimicrobial, Ayurveda, Essential oil, Herb, Thymol, Trachyspermum ammi*

How to cite this article: Kumari L, Lata S, Solanki N, Kumar S, Kumar S, Yadav NK., Phytochemical Constituents and Diverse Pharmacological Activities of Trachyspermum Ammi Linn- A Comprehensive Review. Int J Drug Deliv Technol. 2026;16(78s): 693-712; DOI: 10.25258/ijddt.16.78s.80
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

Herbal medicines are used since ancient times to treat different types of disease as they have no or less side effect. According to the WHO, about 80% population of India depend on herbal medicine for treatment (Naaz et al., 2024). Trachyspermum ammi (T. ammi) is one such annual herb grown in Bihar, Gujarat, Madhya Pradesh, Rajasthan and Maharashtra (Nabi et al., 2023). It has various advantages as compared to the other plants due to easy availability and cheap cost (Hanif et al., 2021). It is generally cultivated in the month of October to November and collected in the month of May-June (Bhadra et al., 2020). It has been used since ancient times to treat various diseases both in humans and animals (Ramya et al., 2017). The commonly used parts of plant are seeds (fruit) that are similar to the seeds of caraway or cumin (Chahal et al., 2017). It has been known with different vernacular names in different parts of India as well as world (**Table 1**). The taxonomical classification of T. ammi is described in **Table 2**. In the light of above facts, we have reviewed the research conducted on T. ammi during the last ten years.

The major phytoconstituents of T. ammi are γ-terpinene, carvacrol, α-pinene, p-cymene, α-terpinene and thymol (Goyal et al., 2022). T. ammi is also rich in vitamins, proteins, and minerals like sodium, potassium, calcium, niacin, fatty acid, fibers, thiamine and phosphorus. In Ayurveda, T. ammi has been recommended for boosting metabolism, weight loss, weight management, spleen disorders, liver and digestive system discomfort and for regulating menstrual cycle in women (Vanitha et al., 2025; Prakash et al., 2026). The essential oil present in T. ammi provides it its characteristic flavour and odour (Vharamble et al., 2023). The seeds of T. ammi demonstrate different pharmacological activities like a antifungal (Shokri et al., 2016), anti-diabetic (Amar et al., 2021), antiviral (Roy et al., 2015), antibacterial (Sharma et al., 2018), anticancer (Ramya et al., 2017), antiproliferative (Rahamouz et al., 2021), cardiovascular (Yadav et al., 2026), anti-inflammatory (Aslam et al., 2020), anxiolytic (Soni et al., 2015), bronchodilator (Alamoudi et al., 2025), anticoagulant (Kolbadinejad et al., 2020), aantioxidant (Singh et al., 2017), anthelmintic (Tambe et al., 2020),

**Author for Correspondence: montygunwal@gmail.com*

neuroprotective (Timalsina et al., 2023) and antiatherogenic (Priyaa et al., 2022) activities.

Table. 1: Vernacular names of Trachyspermum ammi in Indian languages as well as foreign languages.

Languages	Vernacular names
Sanskrit	Yamini, Yaminiki
English	Bishops weed, carom seeds
Hindi	Ajwain
Gujrati	Yavan
Dutch	Ajwan
Nepali	Javano
Telugu	Vamu
Punjabi	Lodhar
Tamil	Omam
Kannada	Oma
Oriya	Juani
Bengali	Yamini, Yavan, Javan
Malayalam	Oman
Korean	Ayowan
Turkish	Misiranason
Armenian	Hounastan
Thai	Chilan
China	Xi Ye Cao Guo Qin
Arabic	Kamun Mulki
Kashmiri	Kath

Table 2: Taxonomical classification of T. ammi

Kingdom	Plantae
Subkingdom	Tracheobionta
Phylum	Seed Plant
Subphylum	Angiospermae
Order	Apiales
Class	Dicotyledons
Genus	Trachyspermum
Species	Ammi
Division	Magnoliopsida
Family	Apiaceae

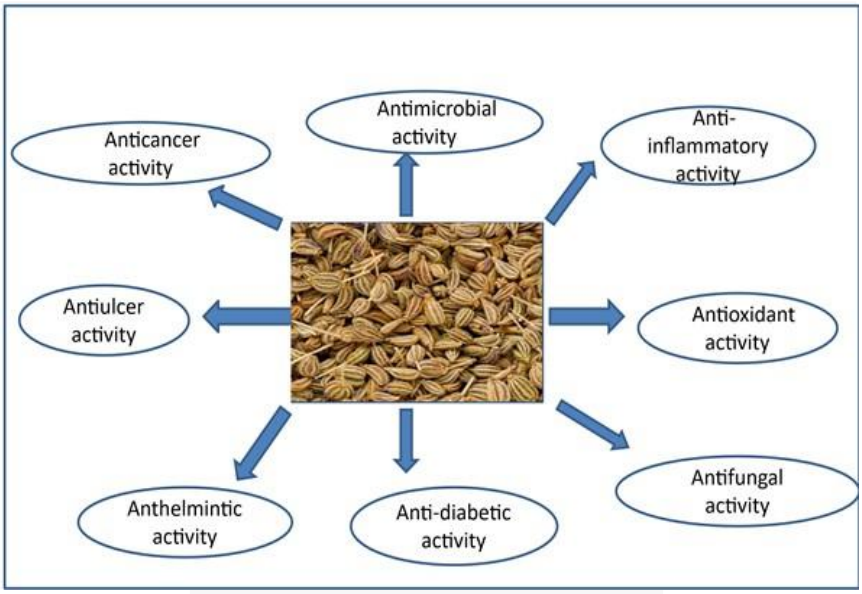


Fig 1. Pharmacological potential of T. ammi

Figure 2. Name of different parts of plant

Antimicrobial activity

Gilani et al. extracted the essential oil from seeds of T. ammi and evaluated its antimicrobial potential against mould (Penicillium digitatum, Aspergillus niger, Mucor, Aspergillus oryzae,), yeast C. utilus (Candida utilus) and bacteria ((Lactobacillus acidophilus, Staphylococcus aureus, Micrococcus luteus, E. coli. The essential oil was found to exhibit excellent antimicrobial effect against Aspergillus oryzae and E. coli with zone of inhibition 14.4mm or 14.3mm respectively. A cream containing T. ammi essential oil was then formulated and evaluated for its physiochemical properties like physiochemical stability, pH and phase separation and in vivo activities such as dermal irritation of cream, excision wound testing of formulation, wound infliction and wound contraction was carried out on rabbits. The results of in vivo activity were compared with Iodine tincture. The formulated cream demonstrated almost wound contraction comparable to Iodine tincture on the 15th day **(Table 3**) (Gilani et al., 2013).

Table 3. In vivo wound healing activity of essential oil from seeds of T. ammi in rabbits

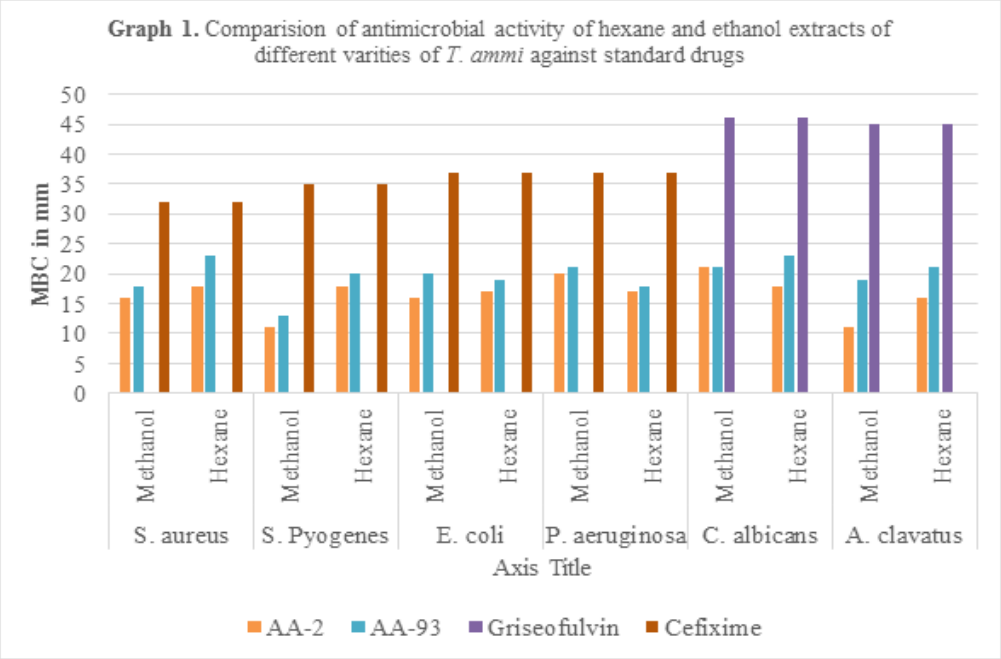
Groups	Wound diameter and Wound contraction in % on 15th day
Control	96
Iodine Tincture	100
T. ammi cream	99

Singh et al. extracted the essential oil from seeds of T. ammi using four different methods hydro-distillation, ultrasonication, solvent extraction, and supercritical carbon dioxide extraction (SC-CO_2). The SC-CO_2 extraction method yielded 2.64% of oil which was highest when compared to other methods- ultrasonication (2.30%), hydro-distillation (1.20%) and solvent extraction (1.82%). The essential oil obtained was evaluated for its antioxidant activity by superoxide scavenging method and Diphenyl picrylhydrazyl (DPPH) method. Ascorbic acid (28.09 ug/ml) was taken as reference drug. The IC_{50} values for essential oil of T. ammi were found to lesser as compared to the reference drug (**Table 4**) (Singh et al., 2017).

Table 4. IC_{50}values of T. ammi essential oil using two different methods

Method	Antioxidant activity IC_{50} (µg/ml)	
	Ascorbic acid (Reference drug)	Essential oil of T. ammi
DPPH	28	36
Superoxide scavenging	20	20

Sharma et al. obtained extracts of two varieties of T. ammi- Ajmer Ajwain (AA-93) and Ajmer Ajwain (AA-2) using methanol and hexane as solvents. The extracts were then evaluated for their antibacterial and antifungal activity against gram-positive bacteria- S. aureus, P. aeruginosa, E. coli, S. Pyogenes, and fungal strains- Aspergillus clavatus (A. clavatus) and C. albicans using zone inhibition method. Bacteria were grown on nutrient agar using spread plate technique or Mueller-Hinton agar while yeast and moulds were grown on potato dextrose agar and Sabouraud dextrose agar media. Cefixime and griseofulvin were taken as a standard antibacterial and antifungal drugs, respectively. This study reveals that hexane extract was more effective against gram-positive bacteria while methanolic extract was more active against gram-negative bacteria for antibacterial potential. Methanolic extract was also more effective than hexane extract against fungi (**Graph 1**) but none of the extracts exhibited activity greater than the standard drug (Sharma et al., 2018).



Sasikumar et al. studied the polyphenolic content of aqueous and methanolic extracts of five Ethiopian spices- Piper capense (P. capense), Thymus schimperi (T. schimperi), Lippia adoensis (L. adoensis), T. ammi, Nigella sativa (N. sativa)] and evaluated their antioxidant potential using three different methods- reactive nitrogen species, DPPH radical assay and reducing power assay \methods. Butyl hydroxy toluene (BHT) and ascorbic acid were taken as a reference drug for comparing the results. The TPC (total phenolic content), (antioxidant activity and TFC (total flavonoid content) was found to be highest in methanolic extract than aqueous extract among all the species taken **(Table 5)**. The total phenolic content in various species followed the order - T. ammi<N. sativa < P. capense < Thymus schimperi < L. adoensis while the total flavonoid content followed the order- P. capense < N. sativa < T. ammi < Thymus schimperi < L. adoensis. All the plant species demonstrated better antioxidant activity than ascorbic acid taken as reference drug. However, the antioxidant activity of all species was found to be lesser than BHT and followed the order- N. sativa< T. ammi< P. capense< Thymus schimperi< L. adoensis (Sasikumar et al., 2020).

Table 5. Antioxidant activity and the contents of five different Ethiopian spices

Spices	TPC (mg GAE/100g DW)		TFC (mg GAE/100g DW)		DPPH assay (IC_{50} µg/ml)	
	Methanolic extract	Aqueous extract	Methanolic extract	Aqueous extract	Methanolic extract	Aqueous extract
L. adoensis	725	580	400	275	49.17	20.99
T. schimperi	680	540	380	245	60.1	149.8
P. capense	330	475	195	210	71.9	205.5
N. sativa	255	460	245	160	94.1	330.2
T. ammi	160	540	345	230	74.4	323.2
Ascorbic acid	-	-	-	-	94.1	17.69
BHT	-	-	-	-	18-20	18-20

Sahukari et al. prepared three extracts of T. ammi using solvents such as acetone, ethanol and methanol. The different extracts obtained were evaluated for their antioxidant and antibacterial potential. The extracts were found to be rich in flavonoids and phenols. The antioxidant effect was performed by reducing capacity, lipid peroxidation and DPPH method. The antibacterial potential of different extracts was evaluated through well-diffusion method against bacterial species such as, S. aureus, Pseudomonas, E. coli. Rutin and streptomycin were taken as a standard antioxidant and antibacterial drugs, respectively. The extracts showed good antioxidant activity using lipid peroxidation nullified, DPPH radical and metal ions (Mo and Fe) reduced. Methanolic extract demonstrated best antibacterial potential against E. coli whereas chloroform extract of T. ammi showed against Pseudomonas and S. aureus (**Table 6)**. Acetone extract demonstrated highest antioxidant activity in lipid peroxidation, reducing capacity as well as DPPH scavenging method (Sahukari et al., 2020).

Table 6: Antibacterial potential of extracts of T. ammi

Extract type	Zone of inhibition (mm)		
	E. coli	**Pseudomonas**	**S. aureus**
Methanolic	**5**	4	5
Chloroform	3	**6**	**6**
Streptomycin (Standard drug)	8	12	12

Ardestani et al., assessed the antimicrobial potential of essential oil of T. ammi obtained using Clevenger apparatus against some vaginal pathogens using broth micro-dilution method. The antimicrobial potential was also assessed for thymol, the most active and abundantly present phytoconstituents of T. ammi, as confirmed by GCMS analysis. The antimicrobial potential of the essential oil was evaluated against bacteria like Gardnerella vaginalis (G. vaginalis), E. coli, Streptococcus agalactiae (S. agalactiae), S. aureus, L. acidophilus and two pathogenic fungi- C. albicans and C. krusei. Tinidazole, nystatin, cefixime and clindamycin were taken as standard drugs against vaginal infection. Trichomoniasis is the most commonly non-viral sexually transmitted infection caused by a parasite, known as T. vaginalis (Trichomonas vaginalis). The percentage growth inhibition of the essential oil was calculated and compared against metronidazole, a standard anti-T. vaginalis drug. The highest bactericidal potential was observed against G. vaginalis, S. agalactiae while thymol was found to be active against C. albicans **(Table 7 and Table 8).** A hundred percent growth inhibition of T. vaginalis was observed at a concentration of 2000 µg/ml for essential oil **(Table 9)** while it was 4000 µg/ml for thymol **(Table 10)**. It is concluded that the component obtained from whole plant showed highest potential against Trichomoniasis than the phytoconstituent isolated from the plant (Ardestani et al., 2020).

Table 7. MIC of essential oil of T. ammi and thymol in comparison to standard drugs

Test drug/ Std. drug	MIC (mg/ml) against used microorganisms						
	E. coli ATCC 25922	**S. aureus ATCC25923**	**S. agalactiae**	**C. krusei PTCC 5295**	**C. albicans ATCC 10231**	**L. acidophilus PTCC 1643**	**G. vaginalis ATCC 49145**
Essential oil	0.5	0.0625	0.0312	0.0625	0.5	0.5	0.06
Thymol	0.0625	0.5	0.0625	0.0625	2	2	0.125
Cefixime	2	0.06	0.03	--	--	--	--
Clindamycin	--	--	--	7.81	31.25	--	--
Nystatin	--	--	--	--	--	4	>500

Table 8. MBC of essential oil of and thymol in comparison to standard drugs

Test drug/ Std. drug	MBC (mg/ml) against taken microorganisms						
	E. coli ATCC 25922	**S. aureus ATCC25923**	**S. agalactia**	**C. krusei PTCC 5295**	**C. albicans ATCC 10231**	**L. acidophilus PTCC 1643**	**G. vaginalis ATCC 49145**
Essential oil	1	4	1	0.5	1	0.5	0.125
Thymol	0.0625	1	0.25	0.25	1	4	0.25
Cefixime	8	0.125	--	--	--	--	--
Clindamycin	--	--	0.06	7.81	31.25	--	--
Nystatin	--	--	--	--	--	8	>500

Table 9. Percentage growth inhibition Trichomonas vaginalis at different concentration of the essential oil

Different concentrations (µg/ml) of essential oil of T. ammi	Growth inhibition (%)	
	After 24h	**After 48h**
125	41	65
250	52	76
750	64	85
1000	80	92
2000	91	92
Negative control	-	-
Metronidazole (50 µg/ml)	100	100

Table 10. Percentage growth inhibition of Trichomonas vaginalis at different concentrations of thymol

Various concentrations (µg/ml) of thymol	Growth inhibition (%)	
	After 24h in %	After 48h in %
125	44	65
250	58	73
750	67	79
1000	77	87
2000	88	93
4000	91	97
Negative control	-	-
Metronidazole (50 µg/ml)	100	100

Metgud et al. obtained ethanol extract from the seeds of T. ammi and determined its antimicrobial potential against two periodontal bacteria- Aggregatibacter actinomycetemcomitans (A. actinomycetemcomitans) and Porphyromonas gingivalis (P. gingivalis) using broth dilution method and streaking method. The MIC and MBC of ethanolic extract against both bacteria were found to be equivalent with their values being 16.66 mg and 33.33 mg, respectively. Hence, it is concluded that ajwain seed is effective for treating chronic periodontal infections caused by these bacteria (Metgud et al., 2021).

Das et al. obtained essential oil from the seeds of T. ammi and assessed its antimicrobial and antioxidant potential. The antimicrobial potential was evaluated against Gram-positive bacteria- Enterococcus faecium (E. faecium), S. aureus and Gram-negative bacteria- Vibrio cholerae (V. cholerae), Pseudomonas aeruginosa (P. aeruginosa), E. coli, Klebsiella pneumoniae (K. pneumoniae), Citrobacter koseri (C. koseri), Salmonella typhi (S. typhi). Ciprofloxacin was taken as a standard antimicrobial drug. Most of the bacteria were less active than the standard drug, ciprofloxacin. However, K. pneumoniae, a drug-resistant bacterium, exhibited equivalent MIC and MBC values in comparision to that of ciprofloxacin that exhibited value of 25 µg/ml **(Table 11**). The results of antimicrobial activity suggest that oil of T. ammi can be a better treatment option against food borne infections caused by drug resistant K. pneumoniae (Das et al., 2022).

Table 11. MIC or MBC of microorganisms for evaluated the antimicrobial effect.

Bacteria	MIC (µg/ml)		MBC (µg/ml)
	Essential oil	Ciprofloxacin (Standard drug)	Essential oil
Gram positive bacteria			
S. aureus	31.25	0.007	62.5
E. faecium	31.25	0.01	62.5
Gram negative bacteria			
E. coli	15.62	0.007	62.5
K. pneumoniae	31.25	0.01	31.25
V. cholerae	31.25	0.01	62.5
S. typhi	31.25	0.01	62.5
C. koseri	31.25	200	62.5
P. aeruginosa	250	0.3	500
Drug resistant bacteria			
P. aeruginosa	250	15.62	1000
K. pneumoniae	7.81	25	7.81

Jabeen et al. prepared nanosuspensions (NPs) from ethanolic extract of T. ammi obtained by Soxhlet extraction method. The nanosuspension and the ethanolic extract both were evaluated for different in vitro activities like cytotoxic, antibacterial, antioxidant and antidiabetic activities. Ciprofloxacin and metformin were taken as a reference antibacterial drug and antidiabetic drugs, respectively. Biochemical characterization was done by High-performance liquid chromatography (HPLC) and Fourier transform infrared spectroscopy (FTIR). HPLC analysis confirmed the presence of Sinapic acid (12.3 ppm), Kaempferol (11.5 ppm) while FTIR confirmed the presence of amines and alcohols. Antibacterial and cytotoxicity activity was determined by biofilm inhibition assay and hemolysis assay, respectively while antioxidant activity was determined using DPPH method. The results of antioxidant activity revealed that the nanosuspension demonstrated more antioxidant potential in comparison to the ethanolic extract. (**Table 12**) (Jabeen et al., 2023).

Table 12. Comparison of various activities among between different assays of extracts and NPs (T. ammi)

Treatments	Total flavonoid content (mg GAE/100 g)	Total phenolic content (mg GAE/100 g)	DPPH method (mg GAE/100 g)	Antidiabetic activity (%)		Biofilm inhibition assay (%)		Haemolysis assay (%)
				Glycation inhibition	α-amylase inhibition	E. coli	S. aureus	
Nanosuspension	157.06	253.04	14.9	25.35	34.6	13.75	-	22.73
Extract	168.28	103.96	43	30.91	45.67	36.91	-	22.69
Control	244.44	750.87	90	56.91	82.53	0.121	0.119	90

Anti-inflammatory activity

Aslam et al. obtained extract from seeds of T. ammi by Soxhlet extraction using various solvents such as chloroform, methanol and n-hexane. The anti-inflammatory potential of the individual extracts was assessed using paw edema method at two different dose concentrations of 500 and 1000 mg/kg. Diclofenac sodium was taken as a reference anti-inflammatory drug. The n-hexane extract demonstrated highest anti-inflammatory potential at effective dose of 1000 mg/kg among all the three extracts and this result was less in comparision to inhibition by diclofenac sodium (**Table 13**) (Aslam et al., 2020).

Table 13. The anti-inflammatory effect of three different extracts at different doses

Treatments	Dose concentration in mg/kg	Inhibition % of paw edema after 4h
Methanolic extract	500	7.80
	1000	8.65
n-hexane extract	500	10.57
	1000	18.26
Chloroform extract	500	7.00
	1000	7.69
Diclofenac sodium (Standard drug)	30	21

Korani et al. obtained aqueous extract of T. ammi seeds and evaluated its anti-inflammatory effect by analysing the inflammatory gene expression in collagen-induced arthritis in Wistar rats and compared against 15 mg/kg ibuprofen, a reference drug. The Wistar rat were divided into four different groups- 1st group received no treatment, 2nd group treated with oral ibuprofen, 3rd group treated with 100 mg/kg of T. ammi aqueous extract and 4th group received combination of aqueous extract and ibuprofen. The effect of four different treated groups on the arthritis score, thickness of paw size and messenger ribonucleic acid (mRNA) level of cyclooxygenase-2 or inducible nitric oxide synthase (iNOS) genes was investigated. The investigations revealed that the reduction in relative COX2 mRNA gene expression and iNOS gene expression was more in case of combined use of aqueous extract of T. ammi and Ibuprofen as compared against T. ammi alone (**Table 14**). Hence, T. ammi aqueous extract can be utilize to treat Rheumatoid arthritis alone or in combination with ibuprofen (Korani et al., 2020).

Table 14. Anti-inflammatory activity by iNOS and relative COX2 mRNA gene expression compared to standard and control

Groups	Relative COX2 mRNA gene expression (Mean)	iNOS gene expression (Mean)
Aqueous extract of T. ammi	6.34	5.67
Aqueous extract of T. ammi + Ibuprofen	4.5	3.45
Ibuprofen	10	6.34
Control	15	13.65

Antiviral activity

Roy et al. obtained essential oil from the seeds of T. ammi using Clevenger apparatus and evaluated its antiviral effects against Japanese encephalitis virus by plaque assay method. The in vitro cytotoxicity was also performed by dimethyl thiazole diphenyltetrazolium bromide (MTT) assay method on African green monkey kidney cell line. The post-exposure treatment with 0.5 mg/ml essential oil of T. ammi led to 40% inhibition as compared to 80% virus present at the time of preexposure treatment. Hence, it is concluded that T. ammi essential oil has the potential

to treat Japanese encephalitis transmitted through mosquitoes (culex sp.) and prevent neuropsychiatric disorders in children (Roy et al., 2015).

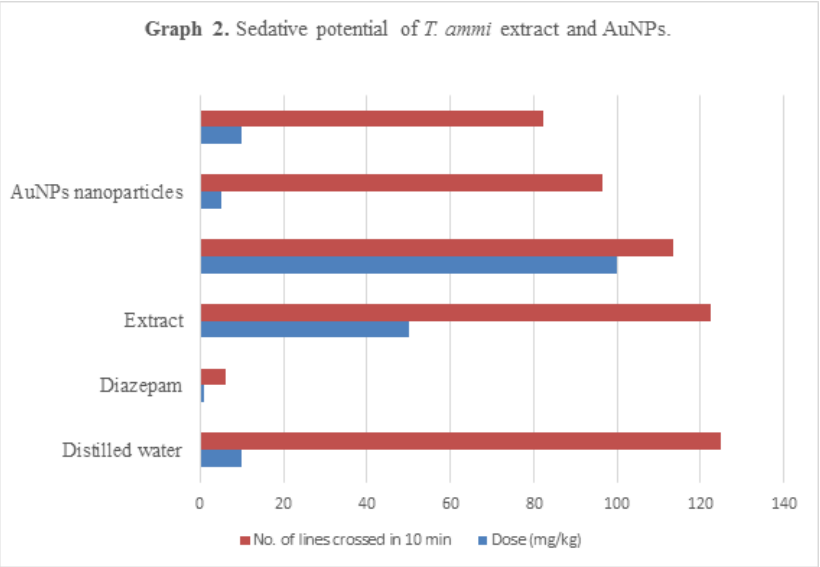
T. ammi Nanoparticles and antibacterial and antioxidant activity

Bawazeer et al. synthesized gold nanoparticles (AuNPs) using the extract of T. ammi and characterized them using FTIR and Ultra violet-visible spectroscopy. The antibacterial capacity of both T. ammi extract and its gold nanoparticles was evaluated by disk diffusion method against K. pneumonia, B. subtilis and S. aureus. Ampicillin, diazepam and diclofenac sodium were taken as antibacterial, sedative and analgesic drugs as standard.

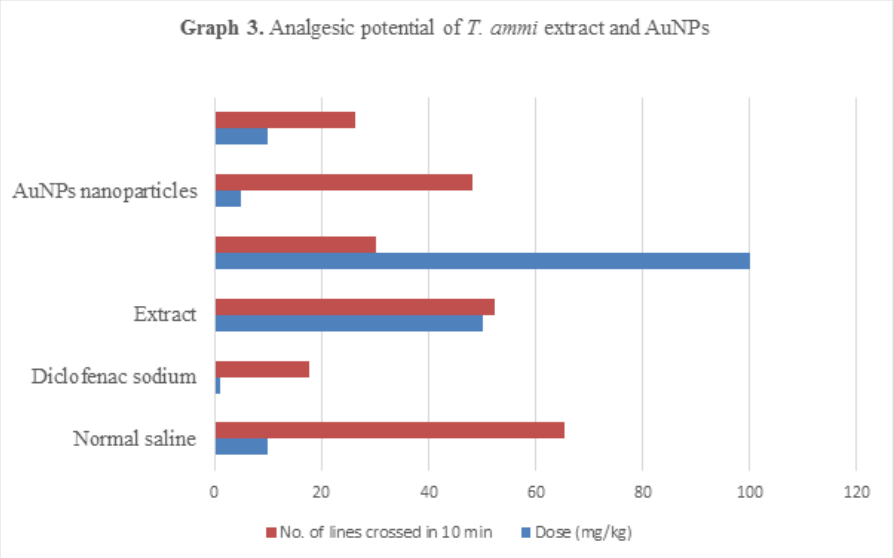
The results of antibacterial activity revealed that both the crude extract of T. ammi and its gold nanoparticles exhibited equivalent activity but against B. subtilis and S. aureus respectively (**Table 15)** but these results were lower in comparison to ampicillin. The extract contains reducing or capping agents that helped to develop stable gold nanoparticles. The gold nanoparticles at concentration of 10mg/kg showed strongest sedation effect **(Graph 2)** and analgesic activity (**Graph 3**) as compared to crude extract but both the activities were less as compared to diazepam and diclofenac sodium respectively. Antioxidant activity of T. ammi extract was the highest in comparision to gold nanoparticles **(Graph 4)** (Bawazeer et al., 2021).

Table 15. Zone of inhibition (ZOI) of T. ammi extract and gold nanoparticles.

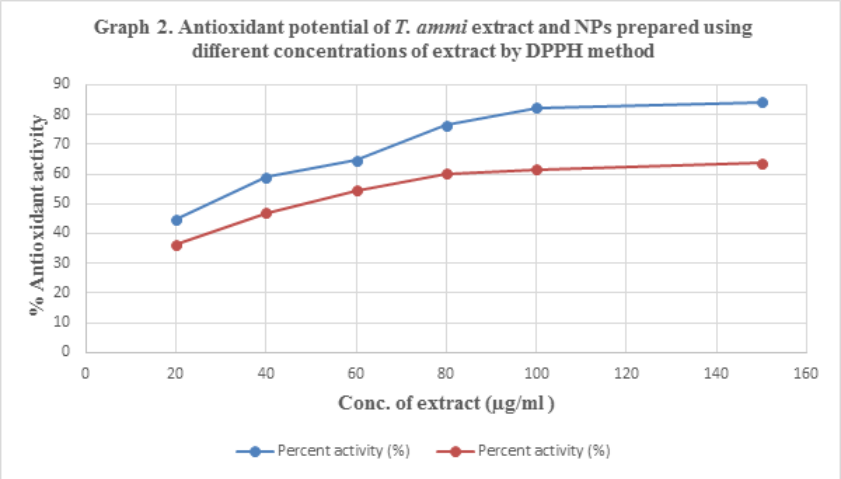
	ZOI (mm)		
	Crude extract	**Gold nanoparticles**	**Ampicillin (standard drug)**
B. subtilis	**10**	0	**30**
S. aureus	0	**10**	**30**
K. pneumonia	0	**0**	**30**



Graph 2. Sedative potential of *T. ammi* extract and AuNPs.



Graph 3. Analgesic potential of *T. ammi* extract and AuNPs



Hanafi et al. obtained T. ammi extract and synthesized its silver nanoparticles using green synthesis method and chemical route using silver nitrate and sodium citrate. The silver nanoparticles were characterized through transmission electron microscopy, X-ray diffraction, FTIR, UV-visible spectroscopy and dynamic light scattering. The antibacterial activity of nanoparticles was assessed through broth microdilution method against five standard bacterial strains- E. faecalis, E. coli, P. aeruginosa, K. pneumonia and S. aureus. Tetracycline was taken as standard antibiotic drug. The nanoparticles synthesised via green synthesis method exhibited better antimicrobial activity against E. coli with MIC of 19µg/ml and 9 µg/ml at 1% and 2% concentration of T. ammi extract as compared to nanoparticles prepared by chemical methods. However, the antimicrobial potential of neither the extract of T. ammi neither the nanoparticles synthesized showed better activity in comparison to tetracycline (0.97µg/ml) (**Table 16**) (Hanafi et al., 2023).

Table 16. Antibacterial potential of T. ammi extract and nanoparticles synthesized via chemical route and green synthesis route in comparison to tetracycline.

Bacterial strain	T. ammi extract	Tetracycline	Chemically synthesized silver nanoparticles		Green synthesized silver nanoparticles	
			Conc. 1%	Conc. 2%	Conc. 1%	Conc. 2%
K. pneumonia ATCC 9997	>40	7.8	>20	>10	75	37.5
P. aeruginosa ATCC 27853	>40	3.9	20	10	19.5	9.7
E. faecalis ATCC 29212	>40	7.8	>20	>10	39	19.5
S. aureus ATCC 25923	>40	0.97	>20	>10	150	75
E. coli ATCC 922	>40	0.97	>20	>10	19	9

Mouthwash

Kumar et al. obtained ethanolic extract from the roots of Achyranthes aspera and seeds of T. ammi using Soxhlet extraction method and prepared their polyherbal mouthwash. The antibacterial activity and cytotoxicity of the mouthwash was assessed against A. actinomycetemcomitans, Tannerella forsythia and P. gingivalis by spread plating method and resazurin microtiter assay, respectively. The MIC and MBC of the individual plant extracts as well as mixture of the two extracts (2:1, 1:2, 1:1, w/v) was determined and compared with that of 0.2% chlorhexidine mouthwash. The antimicrobial activity of the polyherbal mouthwash was found to be lower as compared to the 0.2% chlorhexidine mouthwash (**Table 17**). However, the prepared formulation exhibited better cytotoxicity of 82.1% in comparision to cytotoxicity of 75.5% demonstrated by 0.2% chlorhexidine mouthwash (Kumar et al., 2024).

Table 17. Antibacterial activity of polyherbal mouthwash in comparison to 0.2% chlorhexidine mouthwash

Test organism	Zone of inhibition in mm	
	Herbal mouthwash	0.2% chlorhexidine mouthwash
P. gingivalis	11.30	16.33
Tannerella forsythia	10.50	18.07
A. actinomycetemcomitans	13.43	18.33

Antiepileptic activity

Latha et al. evaluated the in vitro antiepileptic effect of essential oil of T. ammi alone as well as in combination with diazepam in swiss albino rat. Diazepam was taken as a reference antiepileptic drug. The albino rats were given different treatments by dividing in four groups- Group 1- control group- 2% Tween 80 (10mg/kg), Group 2- ajwain oil (test drug), Group 3- standard drug diazepam, and Group 4- 75mg/kg ajwain oil + diazepam (2mg/kg) for finding out its antiepileptic effects. Combination group exhibited excellent protection of 83.33% from seizures in comparision to 66% by reference drug (diazepam) while no effect was observed in group administered with ajwain oil alone. It is concluded that combination treatment showed best antiepileptic activity in maximum electroshock and Pentylenetetrazole model (Latha et al., 2018).

Antidiabetic activity

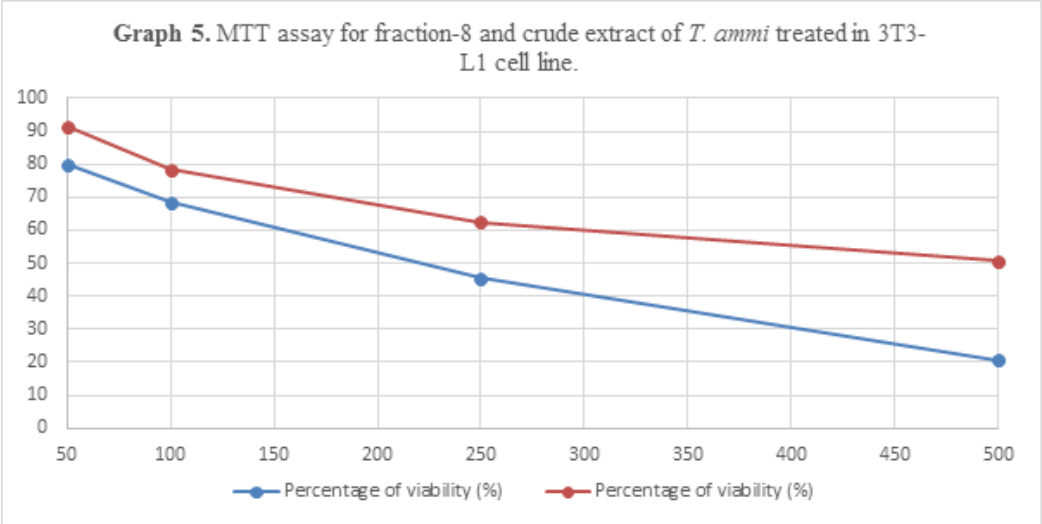
Amar et al. obtained the fractions and subfractions of T. ammi extract by Soxhlet extraction method using ethyl acetate as solvent. A total of 9 fractions were obtained based on mixing the fractions with same Rf values in TLC out of 80 fractions collected from column chromatography. The fraction **8**, exhibited highest α-amylase inhibition activity as compared to the reference drug (Acarbose) (**Table 18**) screened through primary screening using Gel Diffusion assay (Starch-Agar). Fraction **8** was separated again with the help of column chromatography using different solvents (hexane, chloroform, toluene, ethyl acetate and methanol) and four subfractions were obtained based on Rf value of TLC (Subfraction 1, 2, 3 and 4) **(Table 19**). These subfractions were tested for their glucose uptake potential in yeast cells to identify the subfraction with antidiabetic activity. The in vitro antidiabetic potential carried out using glucose-uptake assay of the subfractions and different concentrations of crude extract i.e., 10, 50, 100, 250 and 500 µg/ml was evaluated in 3T3-L1 cell lines by MTT assay (**Graph 5**). Metronidazole was taken as standard drug against glucose-uptake assay. The sub-fraction **1** showed the strongest antidiabetic potential and was found to be most effective than the crude extract (Amar et al., 2021).

Table 18. Inhibitory percentage of α-amylase activity by 9 different fractions of T. ammi extract

Fractions	**ZOI in cm**
Fraction1	1
Fraction 2	0.77
Fraction 3	0.53
Fraction 4	0.86
Fraction 5	No activity
Fraction 6	No activity
Fraction 7	1.25
Fraction 8	**0**
Fraction 9	0.48
Blank (α-amylase)	1.54
Acarbose (Standard)	**0**

Table 19. Effect of sub-fractions of T. ammi extract on the glucose uptake by Yeast Cells.

Subfraction of T. ammi extract (%)	**Concentration in µg/ml**			
	250	**500**	**750**	**1000**
Subfraction 1	79	88	91	**92**
Subfraction 2	40	40	48	69
Subfraction 3	81	82	82	87
Subfraction 4	40	42	49	63
Metronidazole (standard drug)	67	72	76	69



Potential against fruit rot disease of grapefruit

Ali et al. obtained extracts using different plants- seeds of T. ammi and leaves of Callistemon citruns (C. citruns), Chenopodium album (C. album), Lawsonia inermis (L. inermis), Magnifera indica (M. indica) and Cassia fistula (C. fistula) by cold extraction method (**Table 20**). The nanoparticles were further synthesized using T. ammi seed extract to evaluate its potential against Rhizoctonia solani (R. solani), a pathogen responsible for causing fruit rot disease of grapefruit (Citrus paradisi) and compared with the individual leaf extracts of the various plants. The prepared ZnO NPs were characterized using various techniques XRD, Energy dispersive X- ray analysis, FTIR and SEM. Zinc oxide nanoparticles showed best growth inhibition at concentration 1.0 mg/ml in comparision to all other plant extracts. So, it can be concluded that the nanoparticles prepared from T. ammi can be used for preventing fruit rot of grapefruit by further optimization of the formulation (Ali et al., 2022).

Table 20. Antifungal potential of leaf extract from various plants and ZnO NPs

Treatment given	% Mycelial growth inhibition in R. solani	Diseased area after treatment in mm
Extract		
T. ammi seeds	50.9	12.4
L. inermis leaves	19.6	20.1
C. fistula leaves	20.0	18.8
C. album leaves	17.4	28.8
C. citruns leaves	15.7	26.3
M. indica leaves	24.3	17.9
NPs of prepared using various concentrations of T. ammi (mg/ml)		
1.0	70.2	3.1
0.5	48.5	7.1
0.25	1.2	17.9
0.1	0.6	48.1
0	0	60.9
0.75	48.5	5.3

Degradation of Industrial Pollutant

Sethuraman et al. used green method for obtaining extract from seeds of T. ammi and utilized it for synthesizing nickel oxide (NiO) nanoparticles. The synthesized nanoparticles were evaluated their photocatalytic effect against allura red dye and compared against previously synthesized NiO by various methods. The synthesized NiO nanoparticles were evaluated for their antibacterial potential against E. coli and S. aureus. The synthesized nanoparticles exhibited the best degradation effect of 91.73% on allura red dye with a minimum degradation time of 90 min by photocatalytic action of UV-light as compared to other Nio NPs (**Table 21**). The extract behaved as reducing and capping agent in the nanoparticles due to various phytoconstituents and reduced Nickel sulphate to NiO by co-precipitation method. The NiO nanoparticles were also evaluated for their antibacterial potential against S. aureus and E. coli using Resazurin assay technique. The results of antibacterial activity varied with concentration and exhibited inhibitory range of 15.38% to 94.33% against E. coli and 14.38% to 92.56% against S. aureus (Sethuraman et al., 2024).

Table 21. Comparison of degradation efficiency of previously reported literatures.

Nanoparticles	Method of preparation	Dye used	Dye conc. (mgL^{-1})	% Photocatalytic activity	Degradation time (in min)
Nickel oxide nanoparticles	Clitoria ternatea NPs synthesized by green synthesis previously reported in literature	Fast green	20	89	150
	Chemical synthesis (previously reported literatures)	Rhodium- B	5	80.33	120
	Zizyphus jujiba NPs synthesized by green synthesis previously reported in literature	Methylene blue	10	65.5	180
	NPs of Ajwain seeds synthesized by green synthesis for this study	Allura red	10	91.73	90

Antifungal activity

Shokri et al. obtained essential oil from the seeds of T. ammi using hydro-distillation method and evaluated its antifungal potential against 16 fungal pathogenic fungi such as C. glabrata (no. 3), C. albicans (no. 5), C. krusei (no. 1), C. tropicalis (no. 2), C. parapsilosis (no. 1), A. fumigatus (no. 1), Trichophyton rubrum (no. 1), A. niger (no. 1) and Chrysosporium farinicola (no. 1) were used as test microorganisms. The various concentrations of T. ammi essential oil were evaluated for its potential against the fungal species using disk diffusion method. It was found that the essential oil had antifungal potential with mean value of 40.34 mm against Candida species as against other fungal strains (13.5mm) used. Fluconazole was taken as reference antifungal drug. MFC values for yeasts (0.6-1.2 mg/ml) higher than MIC value for moulds (2-5 mg/ml). MIC values of fluconazole (2-64 µg/ml) for Candida species and (32-64 µg/ml) for filamentous fungi (**Table 22**) (Shokri et al., 2016).

Table 22. Antifungal potential of the T. ammi essential oil

Isolates	T. ammi		Fluconazole	
	Microdilution broth in mg/ml		Microdilution broth in mg/ml	
	MIC	MFC	MIC	MFC
C. glabrata	0.35	0.7	64	128
	0.4	0.8	64	128
	0.45	0.9	64	128
C. albicans	0.35	0.7	64	128
	0.3	0.6	8	16
	0.4	0.8	32	64
	0.35	0.7	8	16
	0.35	0.7	4	8
C. tropicalis	0.6	1.2	2	4
	0.5	1	2	4
C. krusei	0.4	0.8	64	128
C. parapsilosis	0.5	1	8	16
A. fumigatus	1	2	64	128
A. niger	1.5	3	64	128
T. rubrum	2.5	5	64	128
C. farinicola	2	4	32	64

Candida species are most common fungus for skin infections, which cause approx. 95% of the fungal infections. Wahab et al. obtained ethanolic extract from the seeds of T. ammi and analysed the antifungal potential of ethanolic extract and thymol containing hexane fraction against C. albicans in in-vivo and in-vitro using Bagg Albino/c mice model. Clotrimazole was taken as a reference drug against candidiasis and Amphotericin B for tube dilution method. The fraction of hexane showed MIC at 225 µg/ml as compared to the 200 µg/ml for amphotericin B. Ethanolic extract of crude drug exhibited 100 percent inhibition at 3200 µg/ml, whereas the MIC showed at 1800 µg/ml. Hexane fraction analysed by GC-MS and indicate the presence of thymol, O-cymene, α-terpinene are 43.91%, 25.53% and 22.64% respectively. The ointment obtained from combination of extract and

fraction was topically used on mice at varying concentrations of 1%, 2.5% and 5% and observed 90-100% recovery in mice in comparision to clotrimazole (reference drug). The hexane fraction demonstrated more effective antifungal potential against candidiasis after 3rd week in comparision to crude ethanolic extract. (Wahab et al., 2021).

Antidermatophytic activity

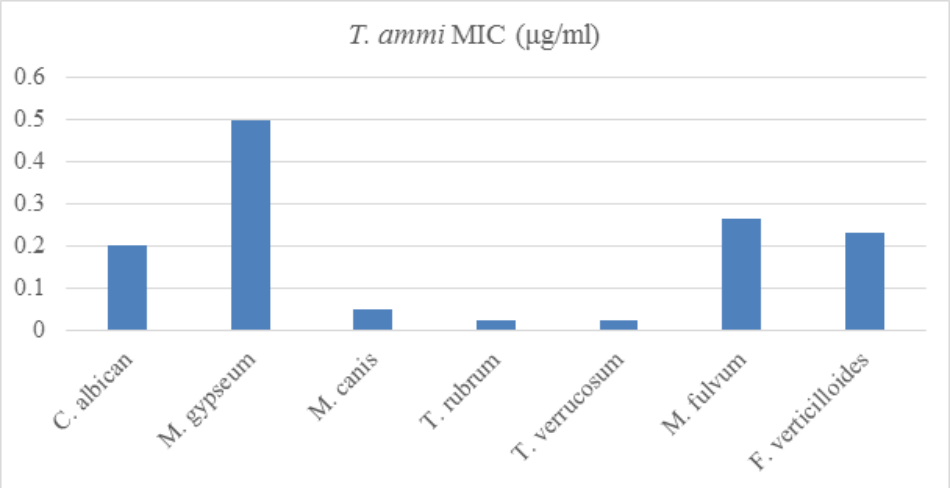
Jain et al. obtained essential oil from the seeds of T. ammi using Clevenger apparatus. The in vitro antidermatophytic activity was performed on microorganisms isolated from skin scrapings of tinea patient- Microsporum gypseum (M. gypseum), Trichophyton simii (T. simii), C. albicans, Trichophyton rubrum (T. rubrum), Trichophyton verrucosum (T. verrucosum) and isolated from soil sample- Fusarium verticilloides (F. verticilloides), Microsporum canis (M. canis), Chrysosporium tropicum (C. tropicum), Chrysosporium indicum (C. indicum) and Microsporum fulvum (M. fulvum) that cause different diseases. Thymol, 58.89%, was the major phytoconstituent present in T. ammi while other constituents such as γ-terpinene, p-cymene, β-pinene were present in lesser amount as analyzed by GC and GC-MS. Ketoconazole, Griseofulvin and itraconazole were taken as antifungal reference drug for comparing antifungal potential. The essential oil was screened for antidermatophytic activity using disc diffusion method, MIC values were determined by semisolid method (**Graph 6**) while toxicological study was carried out using swiss albino mice. C. tropicum showed maximum inhibitory potential with zone of inhibition of 63.83mm as compared to other tested fungi (**Table 23**). Glass oven technique based on temperature differences was used to obtain five various fractions of essential oil of T. ammi which were labelled as TA^{I}-TA^{V} (**Table 24**). Best results of TA^{V} were observed against M. gypseum as comparision to other (Table 21). The essential oil up to 3% concentration did not show any irritation, 5% concentration showed mild erythema, while 7% concentration showed well defined erythema in all the five mice. Hence, it is concluded that T. ammi essential oil and fractions have best antidermatophytic activity with very less side effect as well as no side effect at low concentration (Jain et al., 2018).

Table 23. Comparision of efficacy of T. ammi oil with commercial antifungal drugs

Test fungi		**Concentration of essential oil**			
		25%	**50%**	**75%**	**100%**
T. rubrum	ZOI in mm	29.66	39.33	47	51.33
	Griseofulvin	1.05	1.40	1.67	1.83
	Itraconazole	1.41	1.67	2.23	2.45
	Ketoconazole	0.48	1.83	0.92	1.01
T. simii	ZOI in mm	32	37	45	57
	Griseofulvin	1.33	1.54	1.87	2.37
	Itraconazole	1.6	1.85	2.25	2.85
	Ketoconazole	0.86	0.99	1.21	1.54
C. indicum	ZOI in mm	22	32	38	45
	Ketoconazole	1.29	1.88	2.23	2.64
C. tropicum	ZOI in mm	32	50.83	55.33	**63.83**
	Griseofulvin	0.91	1.45	1.58	1.82
	Itraconazole	1.88	2.99	3.25	3.74
	Ketoconazole	0.82	1.30	1.41	1.63

Table 24. MIC of T. ammi fractions against dermatophytes

Fraction/Fungi	**TA^{1}**	**TA^{2}**	**TA^{3}**	**TA^{4}**	**TA^{5}**
M. gypseum	0.233	0.1	0.053	0.026	0.015
T. rubrum	0.233	0.233	0.050	0.050	0.020
M. canis	0.333	0.333	0.133	0.133	0.017
C. albicans	0.433	0.533	0.233	0.053	0.05



Graph 6. Comparision of MIC values of essential oil of T. ammi against various fungi

Antipyretic activity

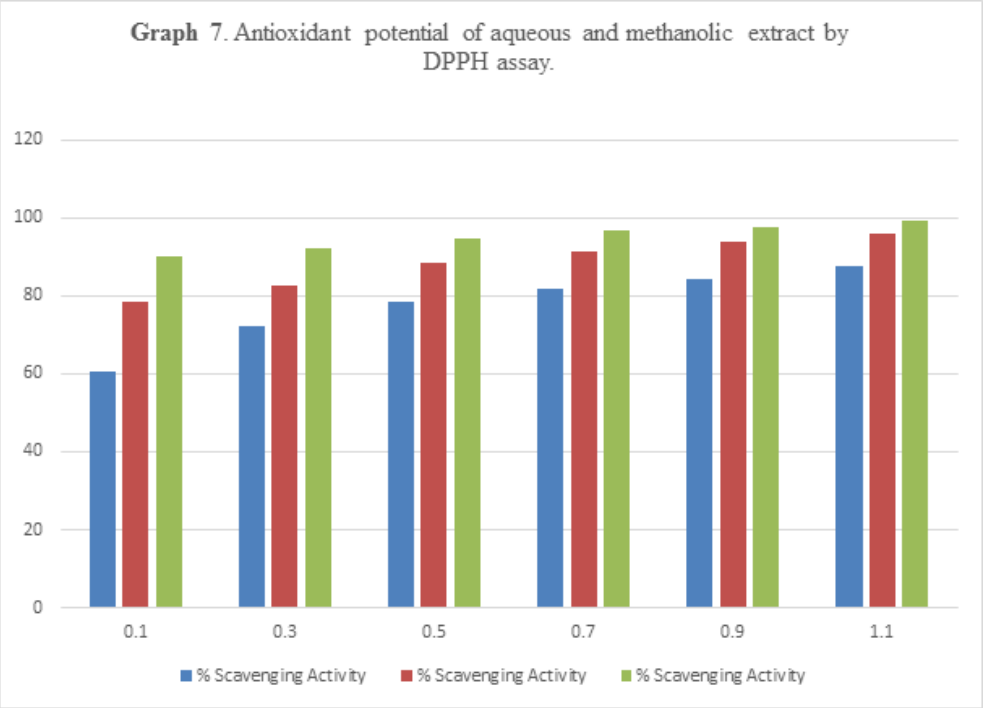
Sultan et al. obtained hydro-methanolic seeds extract of T. ammi through maceration and evaluated its in vivo antipyretic potential. Phytochemical screening of T. ammi showed the presence of 2°metabolites like alkaloids, flavonoids, glycosides, phenols, tannins, saponins, phenols and anthraquinones. The extract at doses of 250mg/Kg and 500mg/Kg was evaluated for antipyretic potential in comparison to 150 mg/Kg paracetamol taken as standard in experimental rabbits by Yeast induced pyrexia method. The results of antipyretic activity revealed that T. ammi extract at a dose of 500mg/Kg significantly reduced rectal temperature in rabbits after an interval of three hours (**Table 25**). It is concluded that extract of T. ammi showed a better antipyretic potential than the reference antipyretic drug, paracetamol (Sultan et al., 2018).

Table-25. Antipyretic effect of T. ammi extract

Groups	Treatment dose (mg/kg)	Rectal temperature °C after drug administration	
		3rd hrs.	6th hrs.
Control	-	39.86	39.7
Extract	250mg/kg	39.11	38.48
Extract	500mg/kg	**38.70**	**38.28**
Paracetamol	150mg/kg	38.57	38.15

Antihyperlipidemic activity

Saleem et al. obtained methanolic as well as aqueous extract of T. ammi seeds using cold extraction method. Both the extracts were evaluated at different doses of 1g/kg, 3g/kg and 5g/kg for their in-vivo antihyperlipidemic potential in hyperlipidemic rats induced by single intraperitoneal (SIP) injection of 100 mg/kg Triton X-100 in normal saline. The results of antihyperlipidemic potential were compared against 10 mg/kg atorvastatin taken as reference drug. The antioxidant activity was also assessed using DPPH method taking Butylated hydroxytoluene as a standard antioxidant drug. The animals were divided in nine groups and each group received the treatment and doses. The blood samples were collected from all animals of each group and examined the serum for the assessing their lipid profiles such as high density lipoprotein, triglycerides, very low-density lipoprotein, low density lipoprotein, and total cholesterol The various biochemical parameters of liver function such as total bilirubin aspartate transaminase and alanine transaminase whereas blood urea nitrogen, creatinine, and albumin were analyzed for renal function test using reference diagnostic kits. The results revealed that methanolic extract T. ammi exhibited best antioxidant potential as compared to BHT and aqueous extract (**Graph 7**). The results of lipid profile indicated that treatment with T. ammi extracts decreased low density lipoprotein, triglycerides **(Table 26**, **27),** cholesterol (**Table 28**) and while improved high density lipoprotein **(Table 29)** (Saleem et al., 2017).



Graph 7. Antioxidant potential of aqueous and methanolic extract by DPPH assay.

Table 26. Effect of T. ammi on low-density lipoprotein levels (mg/dl).

Groups	Induction period (mg/dl)		Treatment days (mg/dl)		
	0 day	2nd day	9th day	16th day	23rd day
Normal control	22.43	21.33	22.30	20.40	21.33
Disease control	18.2	72.39	79.23	94.37	102.41
Atorvastatin (Standard drug)	20.33	90.76	60.83	43.33	17.69
Methanolic extract (1g/kg)	20.77	93.30	91.37	90.67	88.02
Methanolic extract (3g/kg)	21.70	84.47	67.37	55.51	37.54
Methanolic extract (5g/kg)	19.70	82.48	56.60	36.45	20.60
Aq. Extract (1g/kg)	21.47	94.70	92.93	90.01	89.23
Aq. Extract (3g/kg)	20.17	93.50	76.65	60.33	48.50
Aq. Extract (5g/kg)	23.30	91.80	62.71	42.33	25.40

Table 27. Effect of T. ammi extracts on triglyceride level of the treated groups

Groups	Induction period (mg/dl)		Treatment days (mg/dl)		
	0 day	2nd day	9th day	16th day	23rd day
Normal control	103.43	103.30	100.63	102.67	101.00
Disease control	100.40	153.57	166.13	173.30	186.27
Atorvastatin	105.37	91.30	137.33	111.10	91.30
Methanolic extract (1g/kg)	104.23	166.30	162.02	161.96	160.13
Methanolic extract (3g/kg)	102.46	114.43	150.27	131.70	114.43
Methanolic extract (5g/kg)	101.43	96.37	133.40	111.23	96.37
Aq. Extract (1g/kg)	107.47	164.30	163.93	162.01	161.77
Aq. Extract (3g/kg)	107.76	120.13	140.63	129.03	120.13
Aq. Extract (5g/kg)	106.30	103.37	138.80	123.50	103.37

Table 28. Effect of T. ammi on high-density lipoprotein levels of the treated groups

Groups	Induction period (mg/dl)		Treatment days (mg/dl)		
	0 day	2nd day	9th day	16th day	23rd day
Normal control	42.72	43.20	42.77	42.77	43.70
Disease control	40.43	25.13	21.77	19.07	13.80
Atorvastatin	43.10	26.43	34.27	41.03	54.87
Methanolic extract (1g/kg)	42.50	21.17	22.12	22.85	23.10
Methanolic extract (3g/kg)	40.97	24.80	31.50	36.37	41.47
Methanolic extract (5g/kg)	41.33	25.07	32.60	38.70	49.63

Aq. Extract (1g/kg)	41.70	20.70	21.01	21.67	22.01
Aq. Extract (3g/kg)	40.88	22.37	27.63	32.13	36.10
Aq. Extract (5g/kg)	41.67	26.63	33.43	39.43	47.87

Table 29. Effect of T. ammi extracts on total cholesterol level of the treated groups

Groups	**Induction period (mg/dl)**		**Treatment days (mg/dl)**		
	0 day	**2nd day**	**9th day**	**16th day**	**23rd day**
Normal control	85.23	85.23	84.23	83.30	85.20
Disease control	78.17	131.50	134.47	148.10	154.20
Atorvastatin	84.10	149.10	122.10	107.10	90.23
Methanolic extract (1g/kg)	83.50	146.20	143.12	142.96	141.43
Methanolic extract (3g/kg)	82.10	143.10	128.10	116.70	101.10
Methanolic extract (5g/kg)	80.10	141.10	119.30	103.60	90.10
Aq. Extract (1g/kg)	84.23	145.05	144.32	143.00	142.88
Aq. Extract (3g/kg)	83.10	147.10	132.10	119.10	108.60
Aq. Extract (5g/kg)	85.63	150.10	123.10	105.70	97.30

Immunomodulatory activity

Shruthi et al. obtained macromolecular components from the aqueous extract of T. ammi using maceration method and evaluated its immunomodulatory potential. The macromolecular constituents such as, proteins and polysaccharides isolated from various medicinal plants. Polysaccharides from some plants were combined with proteins to form polysaccharides-protein complexes (PPCs). The immunomodulatory properties of PPCs have been assessed. The splenocytes, thymocytes and MLN cells were isolated from spleen, thymus and myeloid lymph node (MLN) of BALB/c mice, respectively. The aqueous extract was precipitated using ethanol (fractionation method), purified by dialysis and separated on DEAE-cellulose column. NaCl was used in five different concentrations such as 0.1, 0.2, 0.3, 0.4 and 0.5M for elution. The eluate containing. 0.4 M NaCl fractions showed the most effective mitogenic potential carried out by MTT assay against splenocytes among all the fractions. This component also demonstrated highest immunomodulatory activity in stimulating the immune system and hence was termed the immunomodulatory component (ImC) of the extract. The ImC of T. ammi exhibited its immunomodulatory action due to presence acidic glycoproteins, polysaccharides and bound phenolic compounds in it. Both ImC and pronase-treated ajwain (termed ImC-Pt) enhanced the nitric oxide release (considered a quantitative index of macrophage activation) from peritoneal exudate cells of rats to 3-fold in comparison to untreated rats and showed phagocytosis at concentration of 10 mg ml^{-1} with $p<0.005$. Bovine serum albumin was used as a reference drug. IMC at concentration of 1µg/ml induced proliferation in murine splenocytes while no proliferation was observed with pronase-treated splenocytes. It is concluded that both polysaccharide and protein constituents of ImC have independent roles in immunomodulatory activity (Shruthi et al., 2017).

Siddiqui et al. obtained extracts using the seeds of T. ammi by Soxhlet extraction method using three different solvents (n-hexane, methanol and chloroform) and evaluated the immunomodulatory potential. Immunomodulatory potential was evaluated through delayed-type hypersensitivity method by measuring the skin thickness of Wistar rats upon oral administration of different extracts of T. ammi. The methanolic extract of T. ammi demonstrated greater increase in thickness of skin compared to other extracts and negative control group after 72 hours of administration of Dinitrochlorobenzene (DNCB) (**Table 30**). The results of acute toxicity demonstrated that 500 mg/kg dose showed immunomodulatory potential in combination with vitamin E, sodium chloride and sodium selenite (Siddiqui et al., 2019).

Table 30. Skin thickness measurement of rats with other groups.

Treatments	**After 24 h**	**After 48 h**	**After 72 h**
Sterile water for injection + water	2.1	2.2	2.3
Methanol	**2**	1.9	**2 ± 0.01**
Methanolic extract	2.9	2.8	2.7
n-hexane extract	2.7	2.8	2.5
Chloroform extract	2.7	2.6	2.6
Immunomodulator	3	3.7	3.2

Antispasmodic activity

Saini et al. hydro-distilled Cuminum cyminum (C. cyminum), Foeniculum vulgare (F. vulgare), T. ammi and Anethum graveolens (A. graveolens) individually to obtain volatile oil of each plant separately. A polyherbal formulation was prepared by mixing all the volatile extracts obtained, adding pulverized saccharin and peppermint as flavouring agent to enhance the palatability of the formulation. Authors selected other three plant that have same medicinal effect- Coriandrum sativum (C.

sativum), Apium graveolens (A. graveolens) and Pimpinella anisum (P. anisum) **(Table 31**). The formulation was standardized by GC technique. The formulation was evaluated for its in vitro antagonistic action on Ach (acetylcholine) induced contractions in guinea pig ileum. The efficacy of gastric motility was assessed through in vivo intestinal transit time of charcoal in mice. Atropine and loperamide were used as a standard antispasmodic drug. The oral administration of polyherbal formulation at a dose of 10-50 µg/ml caused moderate spasmolytic effect which was dose dependent and reversible. The formulation reduced the intestinal transit in mice in a dose-dependent manner in comparision to atropine at concentration 0.1 mg/kg. A dose of 300 mg/kg formulation protected mice against diarrhea when compared to control and reference drug loperamide. The IC_{50} values for antispasmodic activity of polyherbal formulation and atropine were found to be 72.5 µg/ml and 166.7µl/ml, respectively (Saini et al., 2015).

Table 31. IC_{50} value of different medicinal plants

Plant name	**IC_{50} (µl/ml)**
C. sativum	747.1
A. graveolens	80.4
T. ammi	111.5
C. cyminum	96.7
P. anisum	610.3
F. vulgare	106.5
A. graveolens	464.1
M4 (F. vulgare, C. cyminum, T. ammi and A. graveolens)	172.5
M7 (, F. vulgare, C. cyminum. ammi, A. graveolens, P. anisum A. graveolens and C. sativum	196.5

Anxiolytic activity

Rajput et al. evaluated the methanolic extract of T. ammi obtained by cold extraction method for anxiolytic activity. The anxiolytic activity was investigated by passive avoidance response and hole board test. Passive avoidance response estimates both short and long-term learning and memory while hole board test counts head dips into the holes on a board within a prescribed time. Diazepam at a dose of 1 mg/kg body weight was taken as a standard drug and gum tragacanth at a dose of 10 ml/kg body weight was used as control. The test group received 2% (50mg/kg body weight) methanolic extract. The extract of T. ammi demonstrated decreased count of 17.43 counts/3 minutes in hole board test as compared to control group which is nearly comparable to standard reduction in compartment changing time of 107.2 seconds in passive avoidance response test (Rajput et al., 2015).

Nazeer et al. obtained ethanolic and methanolic extracts of T. ammi leaves by maceration. The in vivo anxiolytic activity of the extract was evaluated on Swiss albino mice using dark and light model. The test group of mice was administered with dose of 2mg/ml of methanolic and ethanolic extract daily for 45 days while the control group received normal saline. The data were analysed by two-way ANOVA, which exhibited highly significant results ($p<0.000$) for both methanolic and ethanolic extracts. It is concluded that both methanolic and ethanolic extracts showed significant anxiolytic activity (Nazeer et al., 2017).

Table 32. Patent granted on T. ammi

Sr. No.	**Inventor**	**Invention**	**Patent file no.**	**Part used**	**Country**	**Year of patent**
1.	Gokaraju Rama Raju, Ganga Raju, Kiran, Raju Alluri, Golakoti, Krishanu Sengupta, Bhupathiraju, Trimurtulu, Ranga Raju Gokaraju	Synergetic dietary supplement compositions for enhancing physical performance	AU2019200802A1	Seeds	Australia	2021
2.	Matthew Mahoney, Drew L. Lichtenstein, Mariya Grega, Mercedes Vazquez-Anon, Graciela B. Arhancet, Jeffery Escobar Monestel, Vivek Kuttappan, Scott Long	Compositions of antimicrobial and their uses	US9801845B2	Seeds	US	2017

3.	Donna and Sean EVANS	Composition for treating pain or inflammation comparing to β-caryophyllene and eugenol	WO2015000064A1	Seeds	WIPO	2015
4.	Ibrahim Abou-Nameh	Methods and compositions of plant micronutrients	WO2009135049A1	Seeds	WIPO	2010
5.	Gregory Brian LEE	Microparticle compositions for the treatment of infection and disease, methods of making the same, or methods of treating subjects with the microparticle compositions	US20200397711A1	Seeds	US	2020
6.	Brian Lee ORWAT, Matthew Alan WARD and David Scharich	Method of disinfecting a thermal control unit	US20170348449A1	Seeds	US	2017
7.	Masayuki Yagi, Hiroshige Kawai, and Yoshikazu Yonei, Masako Shoshihara,	Ages-degrading agent and use thereof	EP2949362B1	Seeds	European Patent Office	2022

FUTURE SCOPE

More preclinical and clinical studies are needed to be carried out to confirm efficacy, safety and toxicity of T. ammi in humans. Further, the drug may be developed into more advanced formulations such as nanoparticles, liposomes, phytosomes, hydrogels etc. in order to induce its therapeutic efficacy and bioavailability. Studies related to its pharmacokinetics, long-term toxicity, herb-drug interaction during treatment of cancer, tuberculosis and other chronic diseases need to be carried out to establish a niche of herbal drugs again in society. The potential of T. ammi against different types of cancers need to be validated through animal studies and clinical trials. Future research should also explore the synergetic effects of T. ammi with conventional drugs for improved therapeutic outcomes.

CONCLUSION

T. ammi is a traditional medicinal herb with various pharmacological activities to its credit. The evidences for these pharmacological activities have been reported in ancient literature but experimental evidences are lacking. The documentation and experimental evidences for traditional knowledge needs to be established through in-silico, in-vivo and in vitro studies. Further well-designed clinical trials may establish their efficacy, standardization, safety, dosage and MOA (mechanism of action). This review is an effort to compile research done in past ten years on T. ammi so that it will be of benefit for further future researchers.

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