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Review

Bioactive potential of *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi* belonging to the family Umbelliferae - Current status

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Emerging antibiotic resistance is a worldwide problem that has led to the need for development of novel antimicrobials. Evaluation of natural products as safe and effective antimicrobial agents is one of the scientific strategies to combat the menace of drug-resistant pathogens. Natural products are in use for the treatment of infectious diseases since times immemorial and plants have been an integral part of traditional medicinal system all over the world. Recent years have witnessed a renewed interest in homemade remedies as an impressive number of modern drugs have been developed from plants. The objective of this review is to provide a consolidated report on traditional uses and biological activities of three medicinal plants *viz*. *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi* which have been extensively used for gastrointestinal disorders.

Key words: Antimicrobials, bioactivity, *Anethum graveolens*, *Foeniculum vulgare*, medicinal plants, *Trachyspermum ammi*.

INTRODUCTION

Antibiotics resistance is an emerging global problem and has serious negative effects in designing the treatment strategies (Levy and Marshall, 2004; Gould, 2009). The multidrug resistant strains or so called 'superbugs' are emerging at a faster rate which leads to an increase in morbidity and mortality. The emergence and spread of antimicrobial resistance is an array of problems caused by various interconnected factors, many of which are related to misuse and overuse of antibiotics. Other factors leading to the need for novel anti-infective agents are their cost and the toxicity related with antibiotic use. All these factors emphasize the need for development of novel antimicrobials. Despite an increasing frequency and severity of antimicrobial resistance, the future development of new anti-microbial agents is threatened by the cessation of research in this field by many major pharmaceutical companies (Norrby et al., 2005; Talbot et al., 2006).

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The key development strategies to combat the emerging drug resistance fall into the following groups: modification of existing agents; genomic approaches; vaccine development; and rational validation of bioactive phytochemicals. Although herbs had been valued for their medicinal, flavouring and aromatic qualities for centuries, the synthetic products of modern age surpassed their importance for some time. However, the blind dependence on these synthetic products is over and people are returning to natural products with a hope of safety and security. The concept of medicare is constantly evolving as complementary and alternative medicine (CAM) therapies are integrated into conventional medicine (Neal, 2001). Ethnopharmacology and drug-discovery using natural products remain important issues in the current target-rich, lead-poor scenario (Patwardhan et al., 2004) as it may serve as lead molecules for the development of novel chemotherapeutic agents. Natural products, either as pure compounds or as standardized crude extracts, can be produced from primary or secondary metabolism of living organisms (plants, animals or microorganisms). Our concern is shifting towards traditional medicinal plants to tap their unexplored bioactive

(a) (b)

Figure 1. (a) Seed and (b) Plant of Dill (*Anethum graveolens* L.).

potential. Nature has been a source of medicinal agents for thousand of years and an impressive number of modern drugs have been isolated from natural sources, notably from plant origin, many based on their use in traditional medicine (Cowan, 1999). Plant-derived substances have recently become of great interest owing to their versatile applications. According to recent estimates about 25% of the drugs used presently come from higher plants (Farooqi and Seeramu, 2001).

India is well known historically as a land of spices and aromatic plants and continues to be one of the leading producers of spices and medicinal plants in the world (Prajapati et al., 2005). Most of the spices and herbs have great pharmaceutical value and have been traditionally used in home based medicines (Arora and Kaur, 1999; Shukla and Gardner, 2006). The family Umbelliferae enjoys a unique place in homemade remedies to treat various gastrointestinal disorders. This family is further subdivided into three sub families: Hydrocotyloideae, Saniculoideae and Apioideae and contains about 275 genera and 2850 species. The present review is an effort to present a consolidated report on the current status of research related to three plants belonging to the family Umbelliferae, subfamily Apioideae; namely *Anethum graveolens*, *Foeniculum vulgare* and *Trachyspermum ammi*.

ANETHUM GRAVEOLENS L.

Classical and Indian vernacular names

The generic name '*Anethum*' is derived from the Greek word 'anethon' and the common name Dill comes from the old Norse word, dylla or dilla which probably means 'to soothe' (Singh and Panda, 2005).

Ayurvedic: Shatpushpaa; Unani: Soyaa; Siddha: Sadakuppai.
Sanskrit: Sthatpushpi; Hindi: Sowa; Punjabi: Soya; English: Dill.

Habitat

Dill (*A. graveolens*) has been cultivated in Mediterranean region, Europe and central Southern Asia since antiquity. It grows throughout India, chiefly in Punjab, Uttar Pradesh, Gujarat, Maharashtra, Assam and West Bengal.

Botanical description

A. graveolens (Dill) is an annual, erect, 50 - 150 cm tall and glabrous herb with hollow, furrowed and branched stems; alternate, multipinnate and feathery leaves. The yellowish flowers are arranged in compound terminal umbels. The brown coloured fruit is tiny, oval and flat (Figure 1).

Phytoconstituents

Constituents of Dill include essential oils, fatty oil, moisture (8.39%), proteins (15.68%), carbohydrates (36%), fibre (14.80%), ash (9.8%) and mineral elements such as calcium, potassium, magnesium, phosphorous, sodium, vitamin A and niacin. Fruits of Dill contain 1 - 4% essential oil comprising of major compounds: carvone (30 - 60%), limonene (33%), α-phellandrene (20.61%), including pinene, diterpene, dihydrocarvone, cineole, myrcene, paramyrcene, dillapiole, isomyristicin, myristicin, myristin, apiol and dillapiol (Ishikawa et al., 2002; Raghavan, 2006). Other constituents of Dill essential oil are furanocoumarin, 5-(4"-hydroxy-3"methyl-2"-butenyloxy)-6,7-furocoumarin,oxypeucedanin, oxypeucedanin hydrate and falcarindiol (Stavri and Gibbons, 2005).

Therapeutic uses and biological activities

Dill has been used as a popular aromatic herb and spice that has a very long history of use going back to more than 2,000 years (Ishikawa et al., 2002). Dill is used ex-

tensively as flavouring agent by the food industry. Dill seeds have been used as household remedy to relief digestive problems such as stomachache, indigestion and flatulence. Dill water is believed to have a soothing effect and is given to babies to treat gripe, relieve hiccups and colic. Dill is also a galactagogue that is known to increase the flow of milk in nursing mothers and will then be taken by the baby in the milk to help prevent colic. Chewing the seeds reduce bad breath. Dill has been reported to possess antihyperlipidaemic and antihypercholesterolaemic activity (Yazdanparast and Alavi, 2001; Yazdanparast and Bahramikia, 2008) while on the contrary, Kojuri et al. (2007) did not find any hypolipidaemic effects of *A. graveolens*. However, in another study carried out by Hajhashemi and Abbasi (2008), dill powder and its essential oils have shown hypolipidaemic activity in rats, suggesting its possible use as a cardioprotective agent. Dill has also been reported as anticancer (Zheng et al., 1992); anti-diabetic (Panda, 2008); antioxidant (Al-Ismail and Aburjai, 2004; Satyanarayana et al., 2004; Bahramikia and Yazdanparast, 2009); antisecretory (Hosseinzadeh et al., 2002); antispasmodic (Naseri and Heidari, 2007); cytotoxic to human lymphocytes (Lazutka et al., 2001); insecticidal (Mazyad et al., 1999; Khalaf, 2004; Chaubey, 2008; Seo et al., 2009); and diuretic (Mahran et al., 1992). In a study carried out by Monsefi et al. (2006) using female rats to assess the effect of *A. graveolens* on female reproductive system, it has been found that dill can be used as a regulatory agent of the menstrual cycle.

Antimicrobial properties

Essential oil and extract of dill have been reported to possess various degrees of antimycobactetial activity and this property may probably be due to the presence of furanocoumarin in dill (Stavri and Gibbons, 2005). D-limonene and D-carvone, have exhibited strong antifungal activity against *Aspergillus niger*, *Saccharomyces cerevisiae* and *Candida albicans* (Delaquis et al., 2002; Jirovetz et al., 2003; Stavri and Gibbons, 2005).

The essential oils and acetone extracts obtained from the seeds of *A. graveolens* have shown antimicrobial activity (Singh et al., 2002; 2005). Lopez et al. (2005) demonstrated antimicrobial activity of essential oils (EOs) of dill against four Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus cereus*, *Enterococcus faecalis*, and *Listeria monocytogenes*), four Gram-negative bacteria (*Escherichia coli*, *Yersinia enterocolitica*, *Salmonella choleraesuis* and *Pseudomonas aeruginosa*) and three fungi (a yeast, *Candida albicans* and two molds, *Penicillium islandicum* and *Aspergillus flavus*) with a rationale to test the possibility of creating a protective atmosphere by using natural compounds that could extend the shelf life of packaged foodstuffs; except *P. aeruginosa*, which was totally resistant. Dill seed extracts have also been reported to possess anti-ulcer activity (Rifat-uz-Zaman et al., 2004) and have shown moderate activity against *Helicobacter pylori* (Rifat-uz-Zaman et al., 2006). Aqueous and organic extracts of seeds have exhibited potent antibacterial activity (Arora and Kaur, 2007; Kaur and Arora, 2008, 2009).

FOENICULUM VULGARE MILL.

Classical and Indian vernacular names

The name *Foeniculum* was given by Romans to this plant and is derived from a Latin word ‘foenum’ which means ‘hay’, perhaps because smell of fennel resembles that of hay (Singh and Panda, 2005).

Ayurvedic: Mishreyaa; Unani: Baadiyaan; Siddha: Sogikeenai.
Sanskrit: Madhurika; Hindi: Bari saunf; Punjabi: Saunf; English: Fennel.

Habitat

Fennel is a native of Mediterranean region and Europe but is commonly cultivated throughout India especially in Assam, Maharashtra, Punjab and Gujarat.

Botanical description

Fennel is a biennial or short-lived perennial herb attaining a height up to 2 m; stems are erect, furrowed and branched; leaves are pinnate, decompound and finely divided; the small yellow flowers appear in terminal compound umbels. The seeds are oval, ribbed, 5 - 10 mm long, with strong and sweet smell and are blue green at first turning into greenish brown on ripening (Figure 2).

Phytoconstituents

An analysis of fennel shows it to consist of moisture 6.3%, protein 9.5%, fat 10%, minerals 13.4%, fiber 18.5% and carbohydrates 42.3%. Its mineral and vitamin contents are calcium, phosphorous, iron, sodium, potassium, thiamine, riboflavin, niacin and vitamin C. Its calorific value is 370 (Bakhru, 1992). The oil yield (2.5 - 5%) varies according to variety and origin and the highest concentration of fennel oil ranging from 2 - 7% is found in seeds. Fennel volatile oil is a mixture of at least a dozen of different chemicals and the main ingredients are: anethole (40 - 70%), fenchone (1 - 20%) and estragole (2 - 9%) (Bernath et al., 1996; Raghavan, 2006; Cosge et al., 2008); other compounds (α-pinene, chavicole, dipentene, α-limenene etc.) are present in concentration usually less than 1%.

(a)

(b)

Figure 2. (a) Seeds and (b) plants of Fennel (*Foeniculum vulgar* Mill.).

Therapeutic uses and biological activities

Fennel is chiefly known as culinary herb but it is a commonly used household remedy for various medicinal purposes (Sandhu and Heinrich, 2005). Fruits are used as spice and condiment, as carminative and stimulant, also employed as flavouring agent in culinary preparations, confectionary etc. Water extracts are given as a digestive tonic to infants and children. Fennel is often added to purgatives in order to allay their tendency to cause gripe. In a study carried out on rats, *Foeniculum vulgare* has shown a protective effect against ethanol induced gastric mucosal lesions (Birdane et al., 2007). Fennel has shown anticancer (Celik and Isik, 2008; Singh and Kale, 2008); antidementia (Joshi and Parle, 2006); antihirsutism (Javidnia et al., 2003); anti-inflammatory (Choi and Hwang, 2004); antioxidant (Ruberto et al., 2000; Satyanarayana et al., 2004; Faudale et al., 2008; Topal et al., 2008; Barros et al., 2009; Nickavar and Abolhasani, 2009); antiplatelet and antithrombotic (Tognolini et al., 2006, 2007); antispasmodic activities (Ostad et al., 2001) and as curative in infantile colic (Alexandrovich et al., 2003; Savino et al., 2005). It has also been reported to possess bronchodilatory (Boskabady et al., 2004); diuretic (Wright et al., 2007); hepatoprotective (Ozbek et al., 2003); hypotensive (El Bardai et al., 2001); immunomodulatory (Kaileh et al., 2007); insecticidal (Kim and Ahn, 2001; Traboulsi et al., 2005); mosquito repellant activities (Kim et al., 2002, 2004); nematicidal (Oka et al., 2000); and oculohypotensive properties (Agarwal et al., 2008); and pain reliever in primary dysmenorrhoea (Ostad et al., 2001; Modaress and Asadipour, 2006). Anethole has a chemical structure similar to a chemical, called, dopamine, naturally present in the body. Dopamine is known to have a relaxing effect on the intestine and perhaps, explains why fennel has a beneficial effect on infantile colic.

Antimicrobial properties

Essential oil of fennel has been reported to possess antifungal activity (Mimica-Dukic et al., 2003; Soylu et al., 2006). Essential oil and seed extracts of fennel have also shown antimycobacterial and anticandidal activity (Abed, 2007; Camacho-Corona et al., 2008). Fennel essential oils could also be used as possible bio fungicides, alternative to synthetic fungicides against phytopathogenic fungi as it has been reported to reduce the mycelial growth and germination of *Sclerotinia sclerotiorum* (Soylu et al., 2007).

Fennel essential oils showed antibacterial effect against foodborne pathogens such as *Escherichia coli* and *Bacillus megaterium* (Lo-Cantore et al., 2004); *E. coli* and *S. aureus* (Mohsenzadeh, 2007); *E. coli* O157:H7, *L. monocytogenes*, *Salmonella typhimurium* and *S. aureus* (Dadalioglu and Evrendilek, 2004). The essential oils extracted from the seeds of *F. vulgare* have also been shown to possess antibacterial activity against human pathogenic bacteria (Ruberto et al., 2000; Singh et al., 2002; Aridogan et al., 2002). Aqueous and organic extracts of fennel have demonstrated moderate antibacterial activity (Kaur and Arora, 2008; 2009). Hydroethanol extract of *F. vulgare* has shown inhibition of *Campylobacter jejuni* and *H. pylori* (Mahady et al., 2005; Cwikla et al., 2009). In another study using forty eight isolates of *Acinetobacter baumannii* carried out by Jazani et al. (2009), fennel essential oil has shown the potential for the control of multi-drug resistant *A. baumannii* infections. Fennel essential oils may be used as natural bactericides for the control of phytopathogenic and mycopathogenic bacteria responsible for cultivated mushroom diseases (Lo-Cantore et al., 2004). Dillapional, a phenyl propanoid derivative, was found to be an antimicrobial principle of the stems of *F. vulgare*. A coumarin derivative, scopoletin has also been isolated as marginally

(a) (b)

Figure 3. (a) Seed and (b) Plant of Omum (*Trachyspermum ammi*).

active marginally active antimicrobial agent along with compounds (dillapiol, bergapten, imperatorin and psolaren), which were inactive against *E. coli* (Kwon et al., 2002).

TRACHYSPERMUM AMMI L.

Classical and Indian vernacular names

Ayurvedic: Yavaani; Unani: Desi Ajawaayin; Siddha: Omam.
Sanskrit: Yavanaka; Hindi: Ajowain; Punjabi: Ajowain; English: Omum.

Habitat

Cultivation of this plant originated in Egypt. It grows widely around Mediterranean sea and in South-West Asia extending from Iraq to India, particularly North India-Madhya pradesh, Gujarat, Maharashtra, Uttar Pradesh, Punjab, Haryana, Rajasthan, Bihar and West Bengal.

Botanical description

Trachyspermum ammi (Omum) is a small, erect, annual, herbaceous plant with branched leafy stems, feather like leaves (2.5 cm long), 4 - 12 ray flower heads bearing 6 - 16 flowers. The fruits are minute, greyish-brown coloured and egg shaped (Figure 3).

Phytoconstituents

Omum seed analysis has revealed it to contain moisture (8.9%), protein (15.4%), fat (18.1%), fibre (11.9%), carbohydrates (38.6%), tannins, glycosides, saponins, flavone and mineral matter (7.1%) containing calcium, phosphorous, iron and nicotinic acid (Pruthi, 1992). *T. ammi* seeds contain 2.5 - 5% essential oil and the principal constituents of essential oil are phenols- thymol (35 - 60%), carvacrol (11%). The remainder of the oil is called thymene which contains p-cymene (50 - 55%), beta-pinene (4 - 5%), limonene with gamma-and beta-terpinenes (30 - 35%) (Anonymous, 1995; Raghavan, 2006).

Therapeutic uses and biological activities

Omum with its characteristic aromatic smell and pungent taste is widely used as a spice in curries. Its seeds are used in small quantities for flavouring numerous foods, as preservatives, in medicine and for the manufacture of essential oil for ultimate use in perfumery (Pruthi, 1992). In Indian system of medicine, *T. ammi* is administered as a household remedy for stomach disorders, a paste of crushed fruits is applied externally for relieving colic pains; and a hot and dry fomentation of the fruits applied on chest is used as a common remedy for asthma (Anonymous, 1995). *T. ammi* has been shown to possess anti-aggregatory effects (Srivastava, 1988); anthelmintic (Lateef et al., 2006); antihyperlipidaemic (Javed et al., 2006); antifilarial (Mathew et al., 2008); insecticidal (Chaubey, 2008); kidney stone inhibitory (Kaur et al., 2009); molluscicidal (Singh et al., 1997, 1999; Singh and Singh, 2000); mosquito repellent (Pandey et al., 2009); and nematicidal activities (Park et al., 2007).

Antimicrobial activities

Essential oil of fruits of *T. ammi* also exhibited fungal toxicity against *Epidermophyton floccsum*, *Microsporum canis* and *Trichophyton mentagrophytes* at 900 ppm concentration. Fungitoxicity of the oil was thermostable up to 150°C and thymol was identified as the fungitoxic chemical in essential oil (Singh et al., 1986). Its seed extract at 1:20 dilution was reported to possess fungicidal

action against *Rhizoctonia solani*, a causative agent of sheath blight of rice (Ansari, 1995). Omum oil exhibited a remarkable antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhi*, *Shigella dysenteriae* and *Vibrio cholera* (Syed et al., 1986; Anonymous, 1995). The essential oils extracted from the seeds of *T. ammi* showed antibacterial activity (Mayaud et al., 2008; Singh et al., 2002). Extracts prepared in different solvents exhibited variable activity against *E. coli*, *P. aeruginosa*, *S. typhi* and *S. aureus* (Ahmad et al., 1998; Patel et al., 2008), suggesting their centuries old usage in the treatment of gastrointestinal disorders. This historical use of omum seeds to cure various gastro-intestinal disorders has also been scientifically proved in another study carried out by Kaur and Arora (2009) wherein aqueous and organic extracts of omum seeds have also shown their antibacterial effect. Methanol extracts of *T. ammi* showed significant *in vitro* inhibitory effect on hepatitis C virus (HCV) protease at a concentration 100 µg/ml (Hussein et al., 2000).

SUMMARY

Finding healing power in plants is an ancient idea and a number of effective drugs have been developed from plants. All these three plants belonging to the family Umbelliferae are used in traditional medicine to alleviate gastrointestinal disorders and various biological activities have been accredited to these plants. Antimicrobial potential shown by these plants further warrant their exploration for the development of novel effective chemotherapeutic agents.

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