PHYTOCHEMICAL AND PHARMACOLOGICAL REVIEW ON FOeniculum vulgare

Neetu S Jamwal*, Sunil Kumar, A.C Rana
Department of Pharmacology Rayat Institute of Pharmacy, Railmajra, S.B.S Nagar, Punjab 144533, India.

ABSTRACT
Foeniculum vulgare belongs to Umbelliferae family. It is commonly known as Fennel (English) and Saunf (Hindi). Foeniculum vulgare has a long history of usage in traditional medicine against various ailments. In Ayurvedic and other traditional medicinal practices the plant has been used against diseases like anxiety, arthritis, irritable bowel and it will increase urine flow, improves digestive system, and improves milk flow. Important pharmacological activities such as hepatoprotective, antioxidant, antibacterial properties etc were shown by researchers. This review presents a detailed survey of the literature on various traditional uses, phytochemical and pharmacological properties of Foeniculum vulgare.

Keywords: Foeniculum vulgare, pharmacognostic profile, pharmacological activities.

INTRODUCTION
Since from ancient times plants have been used as herbal remedies for the treatment of various diseases and disorders. Many traditional medicines and medicinal plants have been used as a therapeutic agent for the maintenance of the health of the people. 80% population of developing countries depends on traditional medicines. Foeniculum vulgare is one of the medicinal plants which are used for the treatment of various diseases. It is a biennial crop up to the height of 2 meters, with feathery leaves and golden yellow flowers. It is well-known aromatic and medicinal herb belonging to a family Umbelliferae, which is generally considered indigenous to the shores of the Mediterranean Sea and also found near the river banks. It is widely distributed in Argentina, Bulgaria, Germany, Greece, India, and Lebanon. The leaves of this plant grow up to the length of 40 cm and they are dissected into ultimate fragments filiform up to the width of 0.5mm. Flowers are yellow in colors which are produced inside the terminal compound umbels. The fruits of this plant are seeds which are 4-10mm in length. Foeniculum vulgare has two main varieties i.e “Bitter fennel” and “Sweet fennel” which are used as herbal drugs. It is used in various household remedies. Fennel, anise oil, anise
are used in Italian sausage, meat items. It is also used in Italian cookies, anise cakes, bread, cheese, manufacturing pickles, perfumes, cosmetics and soaps\(^2\). Leaves and flowers of fennel are used as salads. Essential oils like anethole are obtained from fennel are extensively used for the treatment of diseases, in perfumeries, in dentrifices as an antiseptic, toothpaste, mouthwashes, soaps, detergents, lotions, skin creams, in tobacco manufacture, and 0.25% oil is used in perfumes. It is also used to mask undesirable odors in drug and cosmetic products. The oil is used for production of anethole and sometimes as sensitizer for bleaching colors in photography\(^3\).

Distribution:
In India *Foeniculum vulgare* is cultivated in various regions of Assam, Punjab, Maharashta and Gujarat. It is also cultivated in Europe, Asia, Temperate regions of Africa and South America\(^4\).

Pharmacognosy:

**Description:**
*Foeniculum vulgare* is a biennial, aromatic and medicinal herb. It is upto 2 meters in height bearing alternative leaves, branched stems and narrowed leaflets. The leaves of this plant bearing sheaths which are longer than blades. Fruits of fennel are greenish in color and have an oblong cremocarp. Friuts are 6-10mm in length and 1-4mm in diameter. Fruits have glabrous mericarp which are dorsally compressed and have semi-cylindrical shape. Flowers of fennel are yellow in color and seeds are of concave shape\(^4\).

**Synonym:**
There are various synonyms of *Foeniculum vulgare*. Like, Anethum foeniculum clairv., A. foeniculum L., A. rupestre Salisb., Fenicular commune Bubani, Foeniculum azoricum Mill., F. capillaceum Gilib., F. dulce DC., F. foeniculum (L.) H. Karst., F. officinale\(^4\).

Organoleptic properties\(^4\):
Organoleptic properties of *Foeniculum vulgare* are:

1. **Odor:** characteristic, aromatic in nature.
2. **Taste:** Sweet to bitter.

**Microscopic characteristic:**
The mesocarp of fennel consists of brownish colored parenchyma. It also consists of brown epithelial cells which are tranversed in the ridges by vascular bundles having one
inner xylem strand and two lateral phloem strands. They also contain lignified fibres. The mesocarp consists of brownish parenchyma which is traversed longitudinally by six large schizogenous vittae. Some of the mesocarp cells of vascular bundles possess lignified reticulate cells. Epidermis is covered with smooth cuticle. Epidermis also contains fewer stomata and no hairs. Endocarp of this plant consists of parallel layer of flattened thin walled cells. Endosperm is composed of thick walled polygonal cellulosic parenchyma, which contains fixed oils and microrosette crystals of calcium oxalate4.

**Powdered plant material:**

The powdered plant material of fennel is grayish-brown to grayish-yellow in color. It contains polygonal secretory cells which are yellowish-brown in color and these cells are associated with the thin -walled transversely elongated cells, which are 2–9 μm wide. It also contains numerous fibre bundles. Endosperm fragments contain aleuronic grains along with very small microrosette crystals of calcium oxalate, and fibre bundles from the carpophores4.

**General identity tests:**

The identity tests have been done for the macroscopic and microscopic examinations of Foeniculum vulgare, thin-layer chromatography is used in the presence of anethole and fenchone, and gas chromatography is used in the presence of anethole, fenchone and estragole4.

**Purity tests**

<table>
<thead>
<tr>
<th>S.no</th>
<th>Purity tests</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>1.</td>
<td>Foreign organic matter</td>
<td>1.5 % peduncles and not more than 1.5 % foreign matter</td>
</tr>
<tr>
<td>2.</td>
<td>Total ash</td>
<td>Not more than 1.5 %</td>
</tr>
<tr>
<td>3.</td>
<td>Acid insoluble ash</td>
<td>Not more than 1.5 %</td>
</tr>
<tr>
<td>4.</td>
<td>Water soluble extractive</td>
<td>Not less than 20%</td>
</tr>
<tr>
<td>5.</td>
<td>Alcohol soluble extractive</td>
<td>Not less than 11%</td>
</tr>
<tr>
<td>6.</td>
<td>Moisture content</td>
<td>Not more than 8%</td>
</tr>
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**Phytochemical screening:** To evaluate the phytochemicals dissolve the extract of Foeniculum vulgare in methanol to ascertain the presence of tannins, saponins, flavonoids, alkaloids, terpenoids5.
PHYTOCONSTITUENTS | FOeniculum vulgare extracts
--- | ---
Tannins | -
Saponins | +
Flavonoids | +
Alkaloids | -
Terpenoids | -
Cardiac glycosides | +

Thin layer chromatography:
The thin layer chromatography of *Foeniculum vulgare* is used to evaluate the various substances which are not identified in Gas chromatography. The TLC was carried out on silica plates. The dried extract of *Foeniculum vulgare* was partitioned into hexane (18.6gm), chloroform (0.8gm), ethyl acetate (0.1gm), and water soluble (0.5gm) portions. Hexane fraction was chromatographed on a silica gel column and successively eluted stepwise with ethyl acetate (90:10, 85:15, 70:30, 50:50 and 0:100). Only two fractions (90:10 and 50:50) were successively rechromatographed on a silica gel column. HPLC was also used for the separation of other various chemical constituents^6^.

Traditional uses:
*Foeniculum vulgare* subsp. *Vulgare var. azoricum*, the vegetable form of fennel, is sometimes confused with anise due to a similarity in flavor to the true anise. *Foeniculum vulgare* has many traditional uses in the treatment of various diseases. All of the aerial portions of fennel are edible, including the flowers. Fennel seeds are baked into breads, biscuits, stuffings and Italian sausages, and added to sweet pickles and sauerkraut. Stems can be grilled with fish, meats and vegetables, and leaves can be added to salads, olives, fish, and snails or used as a garnish. The essential oil from the seeds is added to cosmetics perfumes, pharmaceuticals and soaps. Fennel oil, seeds or extracts are also used to flavor prepared foods including meats, ice cream, candy, baked goods and condiments as well as liqueurs like sambuca, non-alcoholic beverages and toothpaste. In traditional medicine, fennel was used as an aphrodisiac and to encourage menstruation and lactation. It has been used as a galactagogue improving the milk supply of a
breastfeeding mother. This is suggested to be due to the presence of phytoestrogens present in fennel which promote growth of breast tissue. Other uses:

- Irritable bowel
- Increase urine flow
- Breast enlargement
- Promotes menstruation
- Improves digestive system
- Improves milk flow
- Anxiety
- Arthritis
- Water retention
- Appetite suppressant
- Amenhorrea
- Angina
- Asthma
- Heartburn
- Lower blood pressure
- Boost libido
- Respiratory congestion
- Coughs

Chemical constituents:
Large no of studies has been carried out to identified various chemical constituents. Pasirija A et al; (2011) studied the *Foeniculum vulgare* seed which contain about 8% volatile oil (about 50–60% anethole, among others 10–15% fenchone and methylchavicol) flavonoids, coumarins (including bergapten) sterols and (E)-9-octdecenoic acid. It also contains methyl chavicol, d-apenine, camphene etc. Pectin is also obtained from *Foeniculum vulgare* which were extracted under acidic condition. Pectin is composed of uronic acid but also contained some amount of galactose, rhamnose, arabinose. It also contains hydroxycoumarin, stigmasterol, sulfur, fixed oil
Pasrija A et al; (2011) investigated that the analysis of fennel consists 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 A and C. Its calorific value is 370.

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%). The fruit of *Foeniculum vulgare* has been reported to possess the isolation characterization of alkyl glycosides, aromatic compound glycosides, neuclosides and monoterpenoid glycosides. The extract of seeds inhibits the growth of micro-organism, especially *Streptococcus mutans* that are responsible for dental caries and periodontal diseases. The essential oil from the seed is reported to be antibacterial, antifungal, antioxidant, emmenagogue, oxytocic and abortifacient. The fatty acid, petroselenic acid, obtained from the oil, exhibited antimicrobial activity. Anethole is a major constituent of fennel seed/oil which has been found to be an active estrogenic agent with minimal hepatotoxicity and no teratogenic effect. In experiments anethole and fenchone have been shown to have a secretolytic action in respiratory tract.

**Volatile oils:**

Volatile oils are present in the *Foeniculum vulgare* and it plays an important role in treating various diseases. Volatile oils are obtained from the steam distillation of plants or by direct steam distillation. Volatile oils are obtained from various plant sources, except for whale, musk oil and male deer. Volatile oil does not consist of glycerol esters of fatty acids and cannot saponify with alkalis. Instead on exposure to light and air, they become oxidized and resinified. Volatile oils are present in all the tissues, petals of flowers, bark, leaves, pericarp of the fruits, stems and leaves glandular hairs. Volatile oils as a constituents use as external internal applications, in various perfumes industries, cosmetics, soap manufacturers, also used as preservatives and also used as a flavoring agent. Due to their lipid solubility; they are easily resolved through the skin and mucous. It is reported to possess anti-inflammatory effect, anti-septic activity, deodorizing effect. It also possesses some internal applications like expectorating effect, stimulations of secretion of digestive glands, cumulative effects, spasmylytic effect.
Chemical structure of chemical constituents:

1. Anethole:

   ![Anethole structure](image)

2. M ethylchavicol (estragole):

   ![Methylchavicol structure](image)

3. (E)-9-octodecenoic acid:

   ![Octodecenoic acid structure](image)

4. Camphene:

   ![Camphene structure](image)

5. Galactose:

   ![Galactose structure](image)
6. uronic acid:

![Uronic acid structure]

7. Pectins:

![Pectins structure]

Pharmacological uses:

*Foeniculum vulgare* is used traditionally to treat a large number of disorders and diseases, but yet very few pharmacological activities have been found significant. Studies those found to be significant are following:

1. **Antidiabetic activity:**
   Abou N et al., (2011) carried out antidiabetic activity of *Foeniculum vulgare*. Fennel was traditionally reported to be highly recommended for diabetics. The essential oil which is present in *Foeniculum vulgare* possess to exhibit an antidiabetic effect in Streptozotocin-Induced diabetic Rats. In this study rats were divided into 3 groups 10 rats in each group. Group I was taken as normal control and group II was taken as diabetic control. Group III in which diabetic rats received *Foeniculum vulgare* Mill essential oil (30 mg/kg bw orally). The dose was selected according to the LD50. The results has been reported the marked improvements of hyperglycemia and pathological changes induced by streptozotocin after fennel ingestion which can prove its effect as antidiabetic in folk Medicine. A protective effect was obtained by using *Foeniculum vulgare* Mill essential oil to diabetic rats.

2. **Antioxidant activity:**
   Singh G et al., (2006) carried out antioxidant activity of *Foeniculum vulgare* using acetonic extract prepared by soxhlet extraction. Gas chromatography (GC) and Gas
chromatography- Mass spectroscopy (GC-MS) were use for the chemical analysis of the fennel. These techniques showed the presence of 35 components in volatile oils of Foeniculum vulgare. Trans-anethole was the major component. Acetonic extract showed the presence of 9 components. Linoleic acid, oleic acid and palmitic acid were the major components. Different techniques were used for the evaluation of the anti-oxidant activity such as petriplate method; the volatile oil showed complete zone inhibition against Aspergillus niger, Aspergillus flavus, Fusarium graminearum and Fusarium moniliforme.

Another technique was food poison technique in which both extract and volatile oils showed good to moderate zone of inhibition. The antioxidant values were carried out by measuring the peroxide and thiobarbituric acid values for linseed oils. The acetonic extract and volatile oils showed great zone of inhibition as compared to the butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT).

3. Antifungal activity:
Singh G et al., (2006) carried out the antifungal activity of Foeniculum vulgare. The fennel essential oil and its seed extracts have been reported to exhibit anticandidal activity. The essential oil of F. vulgare have been reported to show complete zone of inhibition against Aspergillum niger, Aspergillum flavus, Fusarium graminearum and Fusarium moniliforme.

4. Antimicrobial activity:
Mahady GB et al; (2000) carried out the anti-microbial activity using methanolic extract of the fruits of Foeniculum vulgare which inhibited the growth of Helicobacter pylori in vitro, in this the minimum inhibitory concentration of 50.0 g/ml.

Janseen AM et al; (1986) carried out the evaluation of this activity by using an essential oil obtained from the fruits inhibited the growth of Candida albicans, Escherichia coli, Lentinus lepideus, Lenzites trabea, Polyporus versicolor Staphylococcus aureus and Kloeckera apiculata, Rhodotorula rubra and Torulopsis glabrata in vitro.

Izzo AA et al; (1995) investigated this activity by using another extract, the ethyl acetate extract of the seeds which also inhibited the growth of some microbes such as Shigella flexneri, and an 80% ethanol extract of the seeds inhibited the growth of Bacillus subtilis and Salmonella typhi at concentrations of 250.0 g/ml in vitro.

5. Hepatoprotective activity:
Ozbek, H et al., (2006) carried out hepatoprotective activity of *Foeniculum vulgare*. The *Foeniculum vulgare* also possessed to exhibit the hepatoprotective activity by using carbon tetrachloride-induced liver fibrosis model in rats. Twenty-four rats were divided into four groups of six animals each. All injections were applied i.p. Group I, which served as normal control, received 0.2 mL Isotonic Saline Solution (ISS), group II, which is olive oil control group, received 1.5 mL kg⁻¹ olive oil, group III (CCl₄) received 1.5 mL kg⁻¹ CCl₄:olive oil (1:7) and group IV (FFO) received 0.2 mL kg⁻¹ FFO followed by 1.5 mL kg⁻¹ CCl₄:olive oil (1:7) three times a week for seven weeks (totally 20 doses). The hepatotoxicity produced by chronic carbon tetrachloride administration by increased serum levels of serum aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase was inhibited by *Foeniculum vulgare* essential oil with the decreased in the levels. Bilirubin histopathological studies also suggest that *Foeniculum vulgare* essential oil prevents the development of chronic liver damage. The result of this study clearly shows that *Foeniculum vulgare* essential oil has a potent hepatoprotective action against carbon tetrachloride-induced liver fibrosis in rats.

6. Antithrombotic activity:

*Foeniculum vulgare* have been reported to have antiplatelet properties. Tognolini M et al., (2007) carried out antithrombotic activity of *Foeniculum vulgare*. The main component of the oil, anethole, tested in guinea pig plasma was as potent as fennel oil in inhibiting arachidonic acid. It's also helpful in preventing thrombin-induced clot retraction at concentrations similar to fennel oil. *F. vulgare* essential oil/anethole showed a significant antithrombotic activity in mice which prevents the paralysis which is induced by collagen-epinephrine intravenous injection. *F. vulgare* essential oil and anethole (100 mg/kg oral administration) shows significant results toward ethanol induced gastric lesions in rats. In conclusion, these results indicate that the *F. vulgare* essential oil, and its main component anethole, has been used as antithrombotic agent.

7. Antispasmodic activity:

Forster HB et al., (1980) evaluated the antispasmodic activity of *Foeniculum vulgare*. An ethanol extract of the fruits of *Foeniculum vulgare* possesses antispasmodic activity, which inhibits the acetylcholine and histamine-induced guinea-pig ileal contractions in vitro. An essential oil which is obtained from the fruits of *Foeniculum vulgare*, 25.0 g/ml
and 10.0 g/ml, respectively, inhibited oxytocin- and prostaglandin. An essential oil from the fruits reduced intestinal spasms in mouse intestine.

8. Cardiovascular effects:
Cardiovascular activity of \textit{Foeniculum vulgare} was carried out by Mokkhasmit M et al., (1971) and Haranath PSRK, et al., (1987). Intravenous administration of a 50% ethanol extract of the fruits reduced blood pressure in dogs. An aqueous extract of the fruits reduced blood pressure in rats. The animals were also pre-treated with atropine for better results. It is highly effective in reducing blood pressures. The effect was blocked by pretreatment of the animals with morphine.

9. Anti-osteoporotic activity:
Tanira M et al. (1996) carried out anti-osteoporotic activity of \textit{Foeniculum vulgare}. Essential oil was obtained from the water - distillation of \textit{Foeniculum vulgare} seeds which was reported for its anti-osteoporotic activities. Gas chromatography- Mass spectroscopy (GC-MS) was use for the chemical analysis of the fennel. These techniques showed the presence of 15 components in oils of \textit{Foeniculum vulgare}. Trans-anethole and fenchone were the major components. Activity was evaluated on overactomized rats. Animals were divided into five groups of six healthy female albino rats. Group I was sham operated (control), group II was ovariectomized-vehicle and group III was ovariectomized treated animals receiving fennel essential oil. 500, 750, 1000mg kg\textsuperscript{-1} dose of \textit{Foeniculum vulgare} were use in this activity or estradiol valerate was 5mg kg\textsuperscript{-1} for 30 days. Then the bone mineral density and the uterine weight were analysed which showed that \textit{Foeniculum vulgare} oil has a preventive effect on the development of osteoporosis in ovariectomized rats. It shows the highly protective effect in albino rats.

10. Analgesic and antipyretic activities:
Fariba J et al., (2006) carried out analgesic and anti-pyretic activities of \textit{Foeniculum vulgare}. The ethanolic extract of \textit{Foeniculum vulgare} possesses to have analgesic and antipyretic activity. The intragastric administration of 500 mg/kg body weight (bw) of a 95% ethanol extract of \textit{Foeniculum vulgare} to mice which reduced the sensation or perception of pain which is pyrexia. In mice with yeast-induced pyrexia, treatment with 500.0 mg/kg bw of the same extract reduced rectal temperature from 36.5\textdegree C to 34.7 \textdegree C 90 minutes after administration. Intragastric administration of 500.0 mg/kg bw of a 95%
ethanol extract of the fruits to rats had significant ($P < 0.05$) analgesic activity in the hot-plate reaction test$^{23}$.

11. Gastrointestinal effects:

*Foeniculum vulgare* has been proven to have gastrointestinal effects by Niiho Y et al., (1977). Intragastric administration of *Foeniculum vulgare* fruits $24.0 \, mg/kg \, bw$ increased spontaneous gastric motility in unanaesthetized rabbits; at a dose of $25.0 \, mg/ \, kg \, bw$ the fruits reversed the reduction of gastric motility induced by pentobarbital$^{24}$.

12. Toxicology:

Toxicological studies of *Foeniculum vulgare* were carried out by Shah AH et al., (1991), Opdyke DLJ. (1974, 1976) and Mokkhasmit M et al., (1971). Various acute and chronic studies of *Foeniculum vulgare* possess toxicological studies in mice and rats. The intragastric administration of $3.0 \, g/kg \, bw$ of a $95\%$ ethanol extract of the fruits induced piloerection and also reduced the locomotor activity in mice. Acute (24-hour) and chronic (90-day) oral toxicity studies with an ethanol extract of the fruits were performed in rodents. In the toxicological studies acute doses were $0.5 \, g/kg$, $1.0 \, g/kg$ and $3.0 \, g/kg$ per day and the chronic dose was $100.0 \, mg/kg$ per day. No acute or chronic toxic effects were observed$^{25}$. The acute median lethal dose (LD$50$) of anethole in rats was $3.8 \, mg/kg$ bw after intragastric administration$^{26, 27}$. Intragastric or subcutaneous administration of $10.0–16.0 \, g/kg \, bw$ of a $50\%$ ethanol extract of the fruits to mice had no toxic effects$^{28}$.

13. Hypolipidemic and Anti-Atherogenic Activity:

Mokkhasmit M et al., (2011) carried out hypolipidemic and anti-atherogenic activity of *Foeniculum vulgare*. The aqueous extract of *Foeniculum vulgare* was use for the hypolipidemic and anti-atherogenic activity in mice. Triton WR-1339 (200 mg/kg body weight) induced hyperlipidemia in mice. In this study mice were divided into three groups, Control, hyperlipidemic and hyperlipidemic treated with fennel aqueous extract, administrated by a force-feed. A significant decrease of plasma lipid levels occurred. 24 h after treatment, plasma total, cholesterol, triglycerides, LDL-cholesterol and Apolipoprotein B decreased by $40 \, \%$, $23 \, \%$, $61\%$ and $61\%$, respectively and increased in HDL-cholesterol and apolipoprotein A-I by $85 \, \%$ and $58\%$, respectively. Also, a histological study on heart alterations showed a marked decrease in lipid deposits$^{29}$.

Safety:
The safety profile of various medicinal plants and herbal drugs use to provide health benefits to the pharma world. Due to the less side effects herbal drugs are widely used for the treatment of various diseases. Various herbal drugs recognized as safe and good therapeutic effect.

CONCLUSION

From the time immemorial the medicinal properties of *Foeniculum vulgare* are available both in written and non written format as traditional knowledge. In traditional medicines the plant has been used as a treatment option against anxiety, arthritis, water retention, appetite suppressant, amenorrhea, angina etc. Traditional knowledge regarding the use of this plant is many but the scientific research available today to support this knowledge is limited. Here we have tried to compile all the available information from both traditional and published scientific literatures regarding the medicinal uses of *Foeniculum vulgare*. It will helpful for the future researchers to get the information. This will provide tremendous opportunities for planning and conduct research related to various aspects of this medicinal plant.

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For Correspondence:
Neetu S Jamwal
Email: jamwalneetu25@gmail.com