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#### **RESEARCH ARTICLE**

#### FOENICULUM VULGARE: PHYTOCHEMICAL AND PHARMACOLOGICAL REVIEW.

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## Manuscript Info

#### Abstract

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#### Key words:

phytochemistry, pharmacology, foeniculum vulgare, volatile compound, non volatile compound.

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..... Foeniculum vulgare commonly called fennel has been used in traditional medicine for a wide range of ailments related to digestive, endocrine, reproductive, and respiratory systems. Additionally, it is also used as a galactagogue agent for lactating mothers. The review aims to gather the fragmented information available in the literature regarding morphology, ethnomedicinal applications, phytochemistry, pharmacology, and toxicology of Foeniculum vulgare. It also compiles available scientific evidence for the ethnobotanical claims and to identify gaps required to be filled by future research. Findings based on their traditional uses and scientific evaluation indicates that Foeniculum vulgare remains to be the most widely used herbal plant. It has been used for more than forty types of disorders. Phytochemical studies have shown the presence of numerous valuable compounds, such as volatile compounds, flavonoids, phenolic compounds, fatty acids, and amino acids. Compiled data indicate their efficacy in several in vitro and in vivo pharmacological properties such antimicrobial, as antiviral. antiinflammatory, antimutagenic, antinociceptive, antipyretic, antispasmodic, antithrombotic, apoptotic, cardiovascular, chemomodulatory, antitumor, hepatoprotective, hypoglycemic, hypolipidemic, and memory enhancing property. Foeniculum vulgare has emerged as a good source of traditional medicine and it provides a noteworthy basis in pharmaceutical biology for the development/formulation of new drugs and future clinical uses.

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## Introduction:-

Foeniculum vulgare Mill. is a biennial medicinal and aromatic plant belonging to the family Apiaceae (Umbelliferaceae). It is a hardy, perennial–umbelliferous herb with yellow flowers and feathery leaves. It grows to a height of up to 2.5 m with hollow stems. The leaves grow up to 40 cm long; they are finely dissected with the ultimate segments filiform (thread like) of about 0.5 mm wide. The flowers are produced in terminal compound umbels. The fruit is a dry seed 4–10 mm long. It is generally considered indigenous to the shores of Mediterranean Sea but has become widely naturalised in many parts of the world especially on dry soils near the sea coast and on the river banks. Some authors distinguish two sub-species of fennel, piperitum and vulgare: sub-speciespiperitum has bitter seeds, while sub-species vulgare has sweet seeds which are used as flavouring agents in baked goods, meat and fish dishes, ice creams, alcoholic beverages, etc due to their characteristic anise odour<sup>1</sup>. Morphological differences between these two sub-species are not always clearly defined. It is a traditional and popular herb with a long history of use as a medicine. A series of studies showed that F. vulgare effectively controls numerous infectious disorders of bacterial, fungal, viral, mycobacterium, and protozoal origin<sup>2-6</sup>. It has antioxidant, antitumor, chemopreventive, cytoprotective, hepatoprotective, hypoglycemic, and oestrogenic activities<sup>7-11.</sup>

#### Plant detail:-

- **division**: Tracheophyta
- subdivision class: Magnoliopsida
- order: Apiales
- family: Apiaceae
- genus: Foeniculum
- species: vulgare
- **botanical name**: Foeniculum vulgare



#### General botanical description:-

Fennel is an ancient seasonal herb. The fennel plant originated in the southern Mediterranean region and through naturalization and cultivation it grows wild throughout the Northern, Eastern, and Western hemispheres, specifically in Asia, North America, and Europe. It is cultivated in fields and also grows wild. The herb was wellknown to the ancient Egyptians, Romans, Indians, and Chinese. The Romans grew it for its aromatic seeds and the edible fleshy shoots are still a very common vegetable in southern Italy. Emperor Charlemagne was known to have encouraged its cultivation in Central Europe. It is an indispensable ingredient in modern French and Italian cooking. All parts of the plant are aromatic and can be used in many ways. F. vulgare is an upright, branching perennial herb with soft, feathery, almost hairlike foliage growing upto 6.6 ft. (2 m) tall. This plant looks similar to dill. It is typically grown in vegetable and herb gardens) for its aniseflavored foliage and seeds, both of which are commonly harvested for use in cooking. It is erect and cylindrical, bright green, and smooth as to seem polished, with multiple branched leaves cut into the finest of segments. The leaves grow upto 40 cm long; they are finely dissected, with the ultimate segments filiform (threadlike), about 0.5 mm wide. The bright golden flowers, produced in large, flat terminal umbels, with thirteen to twenty rays, bloom in July and August. Foliage. Stem striate, leaves 34 pinnate, segments filiform, upto 1.6 in. (4 cm) long; leaf bases sheathing. It has a green, sleek, and slippery stem with upright stiff branches and much divided leaves in linear segments ). Rays are 5–30 numbers with 0.39–2.4 inches (1–6 cm) long. Flowers are small, yellow, and found in large flattopped Umbels. Fruits are oblong to ovoid with 0.12-0.2 inches (3-5 mm) long and 1.5-2.0 mm broad. The stylopodium persists on the fruit. The fruits are elongated and have strong ribs. The most esteemed fennel seeds vary from three to five lines in length and are elliptical, slightly curved, and somewhat obtuse at the ends. They are greenishyellow, the colour of hay, from which the term fennel is derived. Wild fruits are short, dark coloured and blunt at their ends, and have a less agreeable flavour and odour than those of sweet fennel. Seeds ripen from September to October. This plant can reproduce from crown or root fragments but freely reproduces from seed<sup>12</sup>.





#### Chemical composition:-Volatile components:-

Several innovative and novel extraction techniques have been employed to isolate volatile components of fennel in different conditions which have resulted in variation both qualitatively and quantitatively. For example, comparison of the volatile composition of fennel has been carried out using direct thermal desorption (DTD) coupled to gas chromatographymass spectrometry. DTD allowed a high recovery of volatiles from small sample sizes without thermal decomposition. Although a high variability was found among samples, showing clear phytochemical differences<sup>11</sup>.

The influence of different hydrodistillation conditions was evaluated from the standpoint of essential oil yield and chemical composition from seeds of fennel. Three hydrodistillation conditions were considered. The main constituents of the oils were: anethole (72.27%-74.18%), fenchone (11.32%-16.35%) and methyl chavicol (.78%-5.29%). The method of distillation significantly affected the essential oil yield and quantitative Composition<sup>12</sup>. A comparison of essential oils extracted by super critical carbondioxide (SCCO<sub>2</sub>) and steam distillation showed different compositions in different species and found that SCCO<sub>2</sub> extraction resulted higher yield thansteamdistillation<sup>13,14</sup>.

Another study conducted on flower, unripe and ripe fruit oils revealed that major components were estragole (53.08%, 56.11%, and 61.08%), fenchone (13.53%, 19.18%, and 23.46%), and alpha-phellandrene (5.77%, 3.30%, and 0.72%), respectively. Minor qualitative and major quantitative variations for some compounds of essential oils were observed with respect to the different parts of fennel<sup>15</sup>. A novel and rapid headspace solvent microextraction followed by gas chromatography-mass spectrometry (HSME-GC-MS) for the analysis of the volatile compounds of fennel is described. A comparison of HSME-GC-MS, solid phase microextraction (SPME)-GC-MS and steam distillation (SD)GC-MS methods showed that the HSME-GC-MS method was simple, inexpensive and effective and can be used for the analysis of volatile compounds<sup>16</sup>.

Further, a subcritical extractor equipped with a three-way inlet valve and an on/off outlet valve has been used for performing subcritical water extractions (SWE) in a continuous manner for the isolation of the essential oil of fennel. The target compounds were removed from the aqueous extract by a single extraction with 5 ml hexane, determined by gaschromatography-flame ionization (GC-FID) and identified by mass spectrometry (MS). The proposed extraction method has been compared with both hydrodistillation and dichloromethane manual extraction. Better results have been obtained with the proposed method in terms of rapidity, efficiency, cleanliness and possibility of manipulating the composition of the extract<sup>17</sup>. Microscopic Raman studies have enabled direct analysis of chemical composition in the plant and demonstrated that anethole, which is the main essential oil component, is present in the whole mericarp with highest concentration at the top of the fruit<sup>18,19</sup>. It should be noted that transanethole, estragole, fenchone, alpha phellandrene, methyl chavicol, p-allyl anisole are the most abundant compounds so far determined from this plant<sup>20,21,22</sup>. Although most of these compounds are known, their complete pharmacological properties remain, in general, underdetermined.

## Non-volatile Components:-

Recently, a few researchers have determined to prepare various extracts from fennel or fennel waste (marc remained after separation of volatile oil) to isolate non volatile components from the drug. Studies conducted on different varieties of fennel at different conditions demonstrated the presence of some potent phenolic and flavonoidal components are presented here.

Total phenolic contents calculated as gallic acid equivalents in wild fennel was found higher than those of both medicinal and edible fennels<sup>23</sup>. A bioguided isolation of an aqueous extract of fennel waste led to the isolation of 12 major phenolic compounds. Eight new compounds were isolated and identified. 3-caffeoylquinic acid, 4caffeoylquinic acid, 1,5-O-dicaffeoylquinic acid, rosmarinic acid, eriodictyol-7-O-rutinoside, quercetin-3-Ogalactoside, kaempferol-3-O-rutinoside, and kaempferol-3-O-glucoside<sup>24</sup>. Qualitative and quantitative differences among the constituents in various fennel teas prepared by classical infusion, microwave decoction, and dissolution were reported. Chlorogenic acid, quercetin-3-O-beta-D-glucuronide were identified by HPLC-DAD and HPLC-MS as constituents of fennel teas. In addition, minor unidentified flavonol constituents were found in two teas<sup>25</sup>. Two diglucoside stilbene trimers and a benzoisofuranone derivative were isolated from fennel fruit<sup>26</sup>. Seven phenolic acids; viz., tannic, gallic, caffeic, cinnamic, chlorogenic, ferulic and vanillic acids were identified on the basis of their retention time with standard compounds and cochromatography<sup>27</sup>. Identification of water-soluble phenolic compounds in fennel waste reported forty-two phenolic substances, 27 of which had not previously been reported in fennel, including hydroxycinnamic acid derivatives, flavonoid glycosides, and flavonoid aglycons<sup>28</sup>. A reversedphase HPLC method for analyzing phenolic compounds in fennel has also been developed. The method was validated for the major phenolic compounds present in fennel plant material: 3-O-caffeoylquinic acid β-CQA), chlorogenic acid, 4-O-caffeoylquinic acid (4-CQA), eriocitrin, rutin, miquelianin, 1,3-O-dicaffeoylquinic acid (1,3diCQA), 5-O-dicaffeoylquinic acid (1,5-diCQA), 1,4-O-dicaffeoylquinic acid (1,4-diCQA) and rosmarinic acid<sup>29</sup>.

# Medicinal uses of foeniculum vulgare:-

Foeniculum vulgare has been extensively used in traditional medicine for a wide range of ailments. Fennel is used in various traditional systems of medicine like in the Ayurveda, Unani, Siddha, in the Indian, and Iranian traditional systems of alternative and balancing medicine. Its stem, fruit, leaves, seeds, and whole plant itself are medicinally used in different forms in the treatment of a variety of diseased conditions. The preparation methods, uses, and application of F. vulgare are well documented in the common ethnobotanical literature lists the ethnomedicinal uses of F. vulgare for 43 different types of ailments in Bolivia, Brazil, Ecuador, Ethiopia, India, Iran, Italy, Jordan, Mexico, Pakistan, Portugal, Serbia, South Africa, Spain, Turkey, and USA. It is used to treat simple ailments (e.g., cough/cold, cuts) to very complicated ailments (e.g., kidney ailments, cancer). It also has a wide range of veterinary uses. F. vulgare is used in many parts of the world for the treatment of a number of diseases, for example, abdominal pains, antiemetic, aperitif, arthritis, cancer, colic in children, conjunctivitis, constipation, depurative, diarrhea, dieresis, emmenagogue, fever, flatulence, gastralgia, gastritis, insomnia, irritable colon, kidney ailments, laxative, leucorrhoea, liver pain, mouth ulcer, and stomachache <sup>32.</sup>

## Pharmacological activities:-

Foeniculum vulgare is officially noted in Ayurvedic Pharmacopoeia as an important part of polyherbal formulations in the treatment of different diseases and disorders. A number of biological-pharmacological studies have been undertaken to evaluate the indigenous uses of F. vulgare. Few extracts of F. vulgare and isolated compounds have been evaluated for several activities, namely, antiaging, antiallergic, anticolitic, antihirsutism, anti-inflammatory, antimicrobial and antiviral, antimutagenic, antinociceptive, antipyretic, antispasmodic, antistress, antithrombotic, anxiolytic, cardiovascular, chemomodulatory action, cytoprotection and antitumor, cytotoxicity, diuretic, gastrointestinal effect, hepatoprotective, human liver cytochrome P450 3A4 inhibitory, hypoglycemic, hypolipidemic, nootropic, and oculohypotensive activities.

## Antidiabetic activity:-

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<sup>37.</sup>

#### Antioxidant activity:-

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. Transanethole 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 wich 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)<sup>34</sup>.

#### Antifungal activity:-

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 <sup>34.</sup>

#### Antimicrobial activity:-

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 50.0ig/ml14. 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 aureu<sup>15</sup> 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 ig/ml in vitro<sup>35.</sup>

#### Hepatoprotective activity:-

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 appllied 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<sup>36</sup>.

#### Antithrombotic activity:-

Foeniculum vulgare have been reported to have antiplatelet properties<sup>37.</sup> 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. Foeniculum vulgare essential oil/anethole showed a significant antithrombotic activity in mice which prevents the paralysis which is induced by collagen-epinephrine intravenous injection. Foeniculum 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 Foeniculum vulgare essential oil, and its main component anethole, has been used as antithrombotic agent.

## Antispasmodic activity:-

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, 25.0g/ml and 10.0g/ml, respectively, inhibited oxytocin- and prostaglandin An essential oil from the fruits reduced intestinal spasms in mouse intestine<sup>38.</sup>

## Cardiovascular effects:-

Cardiovascular activity of Foeniculum vulgare was carried out by<sup>39.</sup> And 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<sup>20</sup>. It is highly effective in reducing blood pressures. The effect was blocked by pretreatment of the animals with morphine.

#### Anti-osteoporotic activity:-

Anti-osteoporotic activity of Foeniculum vulgare. Essential oil was obtained from the water - distillation of 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 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-1 dose of Foeniculum vulgare were use in this activity or estradiol valerate was 5mg kg-1 for 30 days. Then the bone mineral density and the uterine weight were analysed which showed that Foeniculum vulgare oil has a preventive effect on the development of osteoporosis in ovariectomized rats. It shows the highly protective effect in albino rats<sup>40.</sup>

#### Analgesic and antipyretic activities:-

Analgesic and anti-pyretic activities of Foeniculum vulgare. The ethanolic extract of 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 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  $36.5^{\circ}$ C to 34.7 0C 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 hotplate reaction test<sup>41</sup>.

## Gastrointestinal effects:-

Foeniculum vulgare has been proven to have gastrointestinal effects by<sup>42.</sup> 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.

## Antiallergic Activity:-

Methanolic extract of Foeniculum vulgare fruit showed significant inhibitory effect on DNFB- (2,4-dinitrofluorobenzene-) induced delayed type hypersensitivity after oral administration of 200mg/kg once a day for 7 days. The inhibitory effect on immunologically induced swelling suggests the possible immunosuppressive properties of F. vulgare <sup>79</sup>.

#### **Anxiolytic Activity:**

Anxiety is the unpleasant feeling of fear and concern. When anxiety becomes excessive, it may be considered as an anxiety disorder. Anxiolytic fennel is a drug used for the treatment of anxiety and its related psychological and physical symptoms. Naga Kishore et al. <sup>89</sup> investigated the anxiolytic activity of ethanolic extract of Foeniculum vulgare fruit with the help of elevated plus maze, rota rod, open field test, and whole board models. The 100 to 200mg dose of extract per kg of body weight of animal revealed significant activity when compared to reference anxiolytic drug called diazepam (1mg/kg). Thus, fennel extract may possess anxiolytic activity supporting its traditional claim about anxiolytic activity reported in 19th edition of Pharmacology and Pharmacotherapeutics by Sathodkar, Bhandarkar and Rege.

## Nootropic Activity:-

Alzheimer's disease is a neurodegenerative disorder associated with a decline in cognitive abilities. Dementia is one of the age-related mental problems and a characteristic symptom of Alzheimer's disease. There is some evidence in favor of use of Foeniculum vulgare for the treatment of cognitive disorders like dementia and Alzheimer's disease. Methanol extract of the whole plant of Foeniculum vulgare administered for eight successive days ameliorated the amnesic effect of scopolamine and aging-induced memory deficits in mice. This extract increased step-down latency and acetylcholinesterase inhibition in mice significantly. Thus, Foeniculum vulgare may be employed in treatment of cognitive disorders such as dementia and Alzheimer's disease as a nootropic and anticholinesterase agent <sup>80</sup>.

## Anticolitic Activity:-

Essential oil of fennel regulates the motility of smooth muscles of the intestine, while, at the same time, reducing intestinal gas. Alone, or combined with other plant medicinals, Foeniculum vulgare is indicated in the treatment of spastic gastrointestinal disturbances, in some forms of chronic colitis (which resist other treatments), in dyspepsias from gastrointestinal atony, in dyspepsias with the sensation of heaviness in the stomach, and so forth. The addition of fennel to preparations containing anthraquinonic components reduces the occurrence of abdominal pain often associated with this type of laxative<sup>46.</sup>

#### **Oculohypotensive Activity:-**

The aqueous seed extract of Foeniculum vulgare demonstrated significant oculohypotensive activity using water loading and steroid induced glaucoma model. This extract exhibited 17.49, 21.16, and 22.03% reduction of intraocular pressure in normotensive rabbits at 0.3%, 0.6%, and 1.2% (w/v) concentrations, respectively. A maximum mean difference of 31.20% was observed between vehicles treated and extracts treated eyes in water loading experimental animal model while a maximum mean intraocular pressure lowering of 31.29% was observed in steroid induced model of glaucoma. Thus, the aqueous extract of Foeniculum vulgare revealed oculohypotensive activity, which was found to be as good as that of reference standard antiglaucoma drugs called timolol<sup>47.</sup>

#### **Antimutagenic Effect:0**

Essential oil of Foeniculum vulgare revealed noteworthy protective effects against genotoxicity in mice induced by cyclophosphamide. Genotoxicity and cytotoxicity were assessed by using mice bone marrow chromosomal aberration, micronucleus, and sperm abnormality assays, respectively. Oral administration of essential oil (1 and 2mL/kg) significantly inhibited the frequencies of aberrant metaphases, chromosomal aberrations, micronuclei formation, and cytotoxicity in mouse bone marrow cells induced by cyclophosphamide and also produced a significant reduction of abnormal sperm and antagonized the reduction of cyclophosphamide induced superoxide dismutase, catalase, and glutathione activities and inhibited increased malondialdehyde content in the liver. Additionally, Foeniculum vulgare inhibits the oxidative stress induced by cyclophosphamide<sup>48</sup>.

#### **Chemomodulatory Action:-**

The chemopreventive effect of different doses of test diet of Foeniculum vulgare seeds was examined against 7,12dimethylbenz(a)anthracene- (DMBA-) induced skin papillomagenesis and benzo(a)pyrene- [B(a)P-] induced forestomach papillomagenesis, at the peri-initiational level in Swiss albino mice. Fennel seeds exhibit a significant reduction in the skin and the fore-stomach tumor incidence and tumor multiplicity as compared to the control group. Further, biochemical assays showed a significant increase in the content/activities of phase I enzymes especially in the case of 6% test diet. A concomitant increase in the activities of the phase II enzymes was observed with all the doses of test diet under study. A significant enhancement in the activities of antioxidant enzymes was observed especially at 4% and 6% test diets of fennel. These findings were indicative of chemopreventive potential of fennel against carcinogenesis. This is the first report showing chemopreventive potential of seeds of fennel against carcinogenesis<sup>49.</sup>

#### Hypolipidemic Activity:-

The aqueous extract of Foeniculum vulgare revealed notable hypolipidemic and antiatherogenic activity against Triton WR-1339 induced hyperlipidemia in mice. Aqueous extract causes significant reduction of plasma lipid levels, that is, cholesterol, triglycerides, LDL-cholesterol, and apolipoprotein-B decreased by 40%, 23%, 61%, and 61%, respectively, and increase in HDL-cholesterol and apolipoprotein A1 by 85% and 58%, respectively<sup>50.</sup>

## Antiaging Effects:-

Rasul and his coworker developed a base and formulation containing 4% concentrated seed extract of Foeniculum vulgare. This formulation shows notable antiaging effect with supporting experimental data related to skin moisture and transepidermal water loss (TEWL). The base was insignificant, while the formulation showed significant effects on skin moisture and TEWL. The texture parameter energy showed a significant increase proving that the formulation possesses potential antiaging effects<sup>51.</sup>

# **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, amenhorrea, 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 be helpful for the future researchers to get information about foeniculum vulgare. This will provide tremendous opportunities for planning and conduct research related to various aspects of this medicinal plant.

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