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FENNEL : (FOENICULUM VULGARE MILL.)

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ABSTRACT:-

Foeniculum vulgare Mill 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 as antimicrobial, antiviral, anti-inflammatory, 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.

INTRODUCTION:-

Foeniculum Vulgare is usually a perennial, aromatic plant belonging to Apiaceae (Umbelliferae) family with many subspecies and varieties. *F. vulgare* subsp. *vulgare* var. *Dulce* is called sweet fennel, while *F. vulgare* mill. Subsp. *vulgare* var. *vulgare* is referred to as bitter fennel. Mostly these two varieties are commercially available and are used medicinally. The plant grows wild in Mediterranean region and in European countries of temperate climate but is now cultivated in most parts of the world for commercial purposes. The fruits commonly referred to as seeds are ridged, oblong or ellipsoid shaped, aromatic and are universally known as fennel and by more than 100 other names throughout the world and have been used medicinally since ancient times as one of the ancient Saxon people's nine sacred herbs, fennel was credited with the power of cure and was valued as a magic herb [1,2]. In the middle ages, it was draped over doorways on midsummer's eve to protect the household from evil spirits [3]. Fennel is also one of the most frequently quoted plants in the *Chilandar* medical codex, the best preserved medieval Serbian manuscript on European medical science from the 12th to 15th centuries [4]. Famous Greek physicians, Hippocrates and Dioscorides mentioned fennel as a diuretic and Emmenagogue and its juice was supposed to sharpen the eyesight [5]. The fruits are especially reputed to increase milk secretion, promote menstruation, facilitate birth, alleviate the symptoms of the male climacteric and increase libido [6]. In Indian traditional medicines, it is considered a stimulant, carminative, aromatic, stomachic, Emmenagogue and Galactagogue; the fennel fruit water is traditionally used to relieve flatulent colic and also as a diuretic and diaphoretic in children and infants. A hot infusion is used to treat amenorrhea and to improve lactation, [5,7-12] to improve eyesight and to open liver and spleen obstructions [7]

KEY WORDS:- Introduction, Habitate, Botanical description, Origine and distribution, Cultivation, Phytochemistry, Pharmacological activity.

HABITATE:-

The plant is native to the Mediterranean coasts, cultivated now in Europe, India, China, and Egypt.

BOTONICAL DESCRIPTION:-

Fennel seeds split in to two, one sometimes remaining on the stalk. They are 4-8 mm (1/8-5/16 inch.) long, thin, and curved with colour varying from brown to light green (the green being superior). Fennel is hardly perennial related to parsley, often cultivated as an annual, reaching heights of 1.5-2.5m (5-8ft.). It resembles dill, which it can cross-pollinate with. It should be kept a distance from dill because the resulting seed will have a dulled flavour. The flower heads are collected before the seeds ripen and threshed out when completely dried. Fennel is a beautiful plant. It has a thick, perennial root-stock, stout stem, 4 to 5 feet or more in height, erect and cylindrical, bright green and so much branched bearing leaves segments. The bright golden flowers, produced in large, flat terminal umbels, with from thirteen to twenty rays, are in bloom in July and August. [8]



Fig:1-Plant and seeds of foeniculum vulgare

ORIGINE AND DISTRIBUTION :-

Fennel (*Foeniculum vulgare* Mill) belongs to family Apiaceae. *Foeniculum* is diploid having $2n=22$ chromosomes. It is a native of Southern Europe and Mediterranean region and one of popular seed spice in India mainly grown in Rabi season. Later it spread to the far East and far north in Europe. To the ancient Greeks, fennel represented success and so it was called "Marathon" in reference to the battle, fought in fennel field where the Greeks defeated the Persians in 490 B.C. Fennel was also a symbol of success to the Romans. During the thirteenth century in England, fennel was considered as a royal spice and was served to kings with fruits. The most common Indian name is Saunf and there are many popular regional names. It is widely cultivated throughout the temperate and subtropical regions of the world and major growing countries are Romania, Russia, Germany, France, Italy, India, Argentina and USA. Major fennel producing states in India are Gujarat, Rajasthan, Karnataka, Maharashtra, U.P., Punjab and Bihar. Gujarat and Rajasthan are major fennel producing states.[9]

CULTIVATION:-

Fennel is a stout and aromatic plant crop which is commercially cultivated as an annual herb. Fennel is used in culinary (cooking) and in medicines as well. Fennel belongs to the family of "Apiaceae" and genus of "Foeniculum". Fennel is a hardy, perennial herb with yellow flowers and feathery leaves. This plant is indigenous to the shores of the Mediterranean but has become widely naturalized in many parts of the globe. Fennel is a highly aromatic and flavorful herb that can reach up to 2.5 meters height. India is the top producer of fennel seeds in the world. One can get decent profits by going for fennel seed production by selecting high yielding variety and following good farm management practices.[10]

TAXONOMY:-

- Kingdom : – Plantae
- Clade : – Tracheophytes
- Clade :- Angiosperms
- Clade : – Eudicots
- Clade :- Asterids
- Order :- Apiales
- Family :- Apiaceae
- Genus :- Foeniculum
- Species :- F. vulgare

PHYTOCHEMISTRY:-

Fennel fruits contain alkaloids, carbohydrates, Phytosterols, phenols, tannins, coumarins and flavonoids as nonvolatile substances; the acetone extract is richer in phenols, while methanol extract contains higher amounts of flavonoids [12]. Kaur et al. reported the presence of alkaloids, flavonoids, tannins, saponins and trace amounts of cardiac glycosides in hot water fruit extract and methanol extract of fruit sample from Egypt was reported to contain flavonoids, terpenoids, alkaloids, phenols and sterols; which had estragole (methyl chavicol) (71.1%) as the predominant alcohol, gallic acid (18.9%) as the major phenolic compound and l-limonene (11.9%) as the most prevalent monoterpene hydrocarbon [13]. Major phenolic compounds identified in fennel include 3-o-caffeoylquinic acid, chlorogenic acid, 4-o-caffeoylquinic acid, eriocitrin, rutin, miquelianin, 1,3-o-dicaffeoylquinic acid, 1,5-o-dicaffeoylquinic acid, 1,4-o-dicaffeoylquinic acid and rosmarinic acid; identified flavone (OL)-o-glycosides are quercetin 3-glucuronide, isoquercitrin, rutin, and quercetin 3-arabioside; other phenols reported are kaempferol 3-glucuronide and kaempferol 3-arabioside [14]. Bergapten, columbianetin, osthonol, psoralen, scoparone, seselin, vanillin, beta-sitosterol and stigmasterol have also been identified in fruits. Two diglucoside stilbene trimers and a benzoisofuranone derivative have also been isolated from the fruits [15]. The element present in fennel fruits from Ethiopia were reported as calcium, magnesium, iron, manganese, copper, chromium, cobalt, zinc, nickel and cadmium. Fennel is reported as one of the plant sources with highest amounts of calcium, potassium, sodium and phosphorus. The method of distillation significantly affects the yield and qualitative composition of the essential oil [16]. Essential oil composition also varies depending on the maturation stages of the plant. The yield of Turkish essential oil (5.0ml/kg) and content of trans-anethole are very low (34.8%), whereas yield of essential oil is maximum in fennel from Norway and Austria (50.7 ml/kg and 50.5ml/kg), respectively; these samples are richer in Fenchone (21.2% and 22.8%, respectively), but contain less trans-anethole (64.6% to 63.7%) than samples from Estonia and Moldova (82.0% and 80.9%) [17]. In fennel samples collected from the wild population in the center and south of Portugal, the yields of essential oils varied greatly from 1.1% to 2.9%, and the main constituents, trans-anethole (7.9% to 77.7%), Fenchone (16.9% to 34.7%) and estragole (2.5% to 66.0%) also showed great variations [18]. In general, fennel oil extracted by either distillation-extraction or supercritical fluid extraction shows similar compositions, with trans-anethole, estragole and Fenchone as the main components [19]. Trans-anethole (85.63%) is generally the predominant constituent of the oil, while estragole is found in small amounts (2.87%), and the quantity of Fenchone is <1% [20]. Trans-anethole (69.8%) and limonene (22.5%), though, were identified as the major constituents of essential oil in fennel samples cultivated in southeastern Brazil and Miguel et al. [21] reported estragole as the dominant constituent in the fruit essential oil of samples from Portugal, and trans-anethole, alpha-pinene and limonene being the main components of dried aerial parts essential oil. In samples of essential oil of fennel grown under different climatic conditions in Romania, major compounds identified in all samples were trans-anethole, estragole, fenchone, limonene, alpha-pinene and gamma-terpinene

[22] and fennel oil samples from Egypt also showed trans-anethole, estragole, fenchone and limonene as the major constituents [23]. Essential oils obtained from various wild Italian varieties contained five chemical groups characterized by

- (i) alpha-phell andrene, methyl chavicol (estragole) and trans-anethole;
- (ii) alpha-pinene, limonene and trans-anethole;
- (iii) methyl chavicol and alpha-phell andrene;
- (iv) methyl chavicol and alpha-pinene; and
- (v) alpha-phell andrene [24].

In Chinese medicine various frying methods are used before the fruits are incorporated in poly herbal preparations. After different frying methods, contents of all twenty-four ingredients of the volatile oil from these fruits were changed, and eighteen new compounds, including Linalyl acetate, farnesene, p-allylphenyl aromatic oxide, and Menthone and hexyl octanoate were created; however, transanethole remained the largest of the effective ingredients in the fried samples [25]

PHARMACOLOGICAL ACTIVITY:-

- **ANTI OXIDENT ACTIVITY:-**

The antioxidant activity of wild, edible and medicinal fennels from different Mediterranean countries has been determined. Wild fennel has been found to exhibit a radical scavenging activity higher than that of both medicinal and edible fennels [26]. The methanolic extract of *F. vulgare* fruit has also been reported to exhibit antioxidant activity by decreasing the malondialdehyde level in *F. vulgare* fruit methanol extract group compared to the control group. The essential oil and acetone extracts of *F. vulgare* have been reported to exhibit strong antioxidant activity in comparison with butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) [27]. The inhibitory action of oil and the acetone extracts in linoleic acid system was studied by monitoring peroxide accumulation in emulsion during incubation through ferric thiocyanate method. *F. vulgare* fruit extract and the purified compounds namely cis-miyabenol C11a-O-b-D-glucopyranosyl-(1fi6)-b-D-glucopyranoside, cismiyabenol C, trans-miyabenol C, sinapyl glucoside and syringing 4-O-b-glucoside have been reported to exhibit antioxidant activity. The n-BuOH extract of the *F. vulgare* fruit showed a moderate activity in the lipid peroxidation assay but strong activity at the higher tested concentration. Pure compounds isolated from *F. vulgare* showed higher antioxidant activity than the crude extracts [28]

- **GASTRO-PROTECTIVE ACTIVITY :-**

Pretreatment with fennel water extract significantly reduced ethanol-induced gastric damage in rats, which was suggested to be due to reduction in lipid peroxidation and augmentation in the antioxidant activity [29]. The water extract is reported to increase gastric acid secretion by more than three times of basal secretion in rats that was not blocked by atropine; but significantly -basal acid secretion in aspirin-induced gastric mucosal damage [30]. Oral administration of essential oil and anethole is also significantly protective against ethanol-induced gastric lesions in rats [31]. The antioxidant activity of phenol contents is partly credited for the anti-ulcer effects [29]

- **ANTI-INFLAMMATORY:-**

Methanol fruit extract exhibited inhibitory effects against both acute and sub-acute inflammation and a central analgesic effect, and significantly increased plasma antioxidant enzymes activities and the HDL-cholesterol level [32]. Four coumarins isolated from the fruits showed excellent in vitro antioxidant activity and imperatorin had the greatest anti-inflammatory and antioxidant activities, inhibiting pro-inflammatory cytokines production, including interleukin-6 and tumor necrosis factor- α (TNF- α) in Lipopolysaccharides (LPS)-stimulated raw 264.7 cells [32]. Essential oils from the aerial parts and fruits are also reported to inhibit 5-lipoxygenase enzyme [33].

- **ANTI-BACTERIAL ACTIVITY:-**

The essential oil extracted from the fruits of *F. vulgare* exhibited antibacterial effect against foodborne pathogens such as *Escherichia coli*, *Bacillus megaterium* and *Staphylococcus aureus* [34], *E. coli* 0157:H7, *Listeria monocytogenes* and *S. aureus*. Aqueous and organic extracts of *F. vulgare* have been reported to show antibacterial activity against some bacterial strains [35]. The seed essential oil of *F. vulgare* has also been reported to possess antibacterial activity against some human pathogenic bacteria. Ethanol and water extracts of *F. vulgare* have shown activity against *Campylobacter jejuni* and *Helicobacter pylori* [36]. In another study, the *F. vulgare* essential oil has been shown to exhibit potential for the control of multidrug resistant *Acinetobacter baumannii* infections. Some chemical constituents from *F. vulgare* have been identified as active antimicrobial principles such as a phenyl propanoid derivative – Dillapional was found to be the active antimicrobial principle of the *F. vulgare* stem. Another molecule – Scopoletin which is a coumarin derivative has been isolated from *F. vulgare* and reported to possess marginal antimicrobial effect [37].

- **ANTI-DIABETIC ACTIVITY:-**

The essential oil of *F. vulgare* has been reported to show hypoglycaemic activity in Streptozotocin induced diabetic rats. Ingestion of essential oil of *F. vulgare* to diabetic rats corrected the hyperglycaemia from (162.5 + 3.19 mg/dl) to (81.97 + 1.97 mg/dl) and the activity of serum glutathione peroxidase from (59.72 + 2.78 u/g Hb) to (99.60 + 6.38 /gHb). This makes the possibility of its inclusion in antidiabetic drug industry [38]

- **HEPATO PROTECTIVE ACTIVITY:-**

The fennel essential oil has been reported to possess hepatoprotective activity. In a study, the hepatotoxicity produced by acute CCl₄ administration was found to be inhibited by fennel essential oil with evidence of decreased levels of serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and bilirubin (Ozbek et al., 2003).

CONCLUSION:-

F. vulgare is a medicinal and aromatic plant with a diverse pharmacological spectrum and having considerable importance in particular to food industry. Its aroma active compounds such as anethole (and its polymers like dianethole and photoanethole) estragole, (+)-Fenchone and P-anisaldehyde have been recognised as the biologically active molecules possessing oestrogenic, acaricidal and antithrombotic activities. The phenolic molecules present in fennel have been shown to possess potent antioxidant activity in a number of experiments. These bioactive molecules in fennel can be developed as novel pharmacological lead molecules provide their bioavailability, pharmacokinetics, physiological pathways, and importance to human health are known with sufficient detail.

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