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Original Research Article

Secondary Metabolites Profiling Using FTIR and GC-MS Techniques and Bioactivities of Fennel (Foeniculum Vulgare) Aerial Parts and Evaluation of Its Antioxidant (Singlet Oxygen Scavenging and Hypochlorous Acid Scavenging) Activity

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Abstract: Plants produce numerous biological chemicals of various types. Phytochemicals found in plants seek to reduce the damage free radicals cause because they are abundant in vegetables and fruits. Plants containing high levels of useful phytochemicals in their composition provide dietary supplements that defend our bodies from free radicals. The purpose of this investigation involved analyzing the phytochemicals as well as GC-MS and FTIR properties found in aerial portions extracted with ethanol from Foeniculum vulgare. An electric power grinder chopped the Foeniculum vulgare aerial parts following shade drying at room temperature until they reached the ground state. A Soxhlet extractor worked with 250 ml of ethanol for the extraction of 50 g powdered plant leaves. The prepared mixture needed filtering through whatman paper. The analysis using GCMS determined the bio-active compounds found in Foeniculum vulgare aerial parts that were extracted with ethanol according to this research. Chemicals with biological activity, like β-Pinene, pentadecanoic acid, γ-Terpinene, (R)-(-)-alpha-Phellandrene, Thymol, L-Fenchone, (-)-beta-Copaene, (E)-beta-ocimene, trans-Anethole, beta-Copaene, Dipentene, (E)-3,7-Dimethylocta-1,3,6-triene, oleic acid, n-Octadecane, Behenic acid, alpha-Linolenic acid, n-Capric acid, and palmitic acid. FTIR spectrum indicates the presence of O-H group (alcohol), carboxylic acid, amine, Sulphur derivatives, amino acid, and nitro - compounds among others as recorded (667.37, 69.147, Strong, =C–H, Bending, Alkenes), (894.97, 82.045, Strong, =C–H, Bending, Alkenes), (1029.99, 61.548, Strong, C-F, Stretch, alkyl halides), (1238.30, 81.092, Strong, C-F, Stretch, alkyl halides), (1317.38, 81.874, Strong, C-F, Stretch, alkyl halides), (1373.32, 81. 514, Strong, C-F, Stretch, alkyl halides), (1519.91, 82.843, Medium, C=C, Stretch, Aromatic), (1616.35, 77.669, Bending, N-H, Stretch, Amide), (1743.65, 87.838, Strong, C=O, Stretch, Ester), (2852.72, 87.591, Strong, C-H, Stretch, Alkane), (2920.23, 83.176, Strong, C-H, Stretch, Alkane). The antioxidant activity was measured using leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Lipoic acid (standard)) from Foeniculum vulgare which revealed 68.48 ± 5.30, 55.33 ± 4.91, 52.21 ± 4.83, 53.85 ± 4.40, 62.79 ± 5.00, and Lipoic acid (standard) 52.45 ± 1.13 values. The leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Ascorbic acid (standard)) of Foeniculum vulgare tested for antioxidant activity (Hypochlorous acid scavenging) yielded results of 118.89 ± 6.15, 122.09 ± 6.17, 126.13 ± 6.82, 133.41 ± 7.00, 144.25 ± 7.63 and Ascorbic acid (standard) 220.89 ± 10.91.

Keywords: FTIR, GC-MS, Foeniculum vulgare, aerial parts, Singlet oxygen scavenging, Hypochlorous acid scavenging.

INTRODUCTION

Through the use of plants along with their compounds human societies have treated different medical illnesses since ancient times. Historic times mark the beginning of human knowledge about plant-based medicine with its different healing properties. Time passed and human beings developed curiosity about both the natural habitat and main therapeutic agents of this plant. Plants serve as the main pharmaceutical raw ingredients [1, 2] demonstrating multiple biological properties that include antibacterial and antifungal and antioxidant effects. Healing insufficiency occurs

because many pathogens now possess antibiotic resistance capabilities. The existing antibiotic therapeutic methods operate at very high costs. Multiple scientific investigations reveal that different plants possess strong antioxidant properties. The discovery of plant extracts together with their derivatives prompted their increasing utilization. Research indicates that selected botanical substances can serve as remedies for severe illnesses including cancer [3], blood hyperglycemia and inflammation. Plants serve as vital agents for identifying revolutionary pharmaceuticals and medical substances according to statistical data. Fennel which scientists identify as Foeniculum vulgare exists as a Lamiaceae family plant that originally grew through widespread cultivation in Mediterranean regions before receiving global propagation. Studies prove that fennel plants contain many active chemical elements which are mainly located in their leaves. Scientists regard fennel plant as indigenous to Mediterranean southern Europe though its medicinal properties alongside its high bioactive constituents have made it a global pharmaceutical commodity [4-6]. Fennel serves as a raw ingredient or dried product for leaves, roots and seeds and fruit which industry uses in foods, pharmaceuticals and cosmetic production. For hundreds of years Fennel (Foeniculum vulgare Miller, Apiaceae) has functioned as an historic medicinal and aromatic herb. The plant components employed in Fennel processing include leaves, stems, roots, fruits and oil derived from the fruits. The medicine makes use of dried fruits known as seeds following their natural ripening. Traditional medicine adopts fennel fruits as stimulants and diuretics as well as carminatives and sedatives along with supporting milk production in nursing individuals [7]. Fennel oil serves as a medically recommended remedy to treat indigestion together with wind and bronchitis as well as coughs and sore throats and gum disease. The oil extracted from fennel exists in multiple products such as Sambuca and Fenoullette liqueurs together with toothpaste along with detergent and air fresheners and fragrances. The plant seeds together with its leaf and base components serve as flavoring agents for cheese, liqueur, bread, seafood and salads since ancient times. Every part of fennel contains the anise-like perfume which extends to the essential oil located in fruits to amount between 1-4 percent. The essential oil extract contains three main components which include bitter fenchone together with estragole and sweet anise-smelling trans-anethole. Several investigations in recent times have focused on analyzing the essential oil's chemical composition in fennel seed oil. Research on essential oil chemical makeup remains sparse for extracts taken from fennel plant aerial components such as stems, stalks and leaves [8–10]. This research aimed to evaluate antioxidant properties of Foeniculum vulgare aerial parts ethanolic extract by singlet oxygen scavenging methods and hypochlorous acid scavenging tests while analyzing its phytochemical content and performing GC-MS and FTIR tests.

MATERIALS AND METHODS

Extract preparation

A power electric grinder processed the obtained aerial parts of Foeniculum vulgare after shade drying and separating them at room temperature. надацевARED .50of plant leaf powder subjected to a Soxhlet extraction using 250مل of ethanol. A whatman filter paper conducted the filtration of the obtained mixture. We measured the weight of the obtained materials while putting the remaining portion into dark storage for future experimental purposes. The plant material preservation took place in darkness thus maintaining its natural properties.

FTIR analysis The Fourier-transform infrared spectroscopy (FTIR)

This study determined and identified separate functional groups in powdered leaf ethanol extracts of Foeniculum vulgare using the specified method. One vital characteristic of chemical bonds appears through their unique absorption of specific wavelength light patterns. The evaluation of infrared absorption spectra helps determine the chemical bonds present in molecules. The Shimadzu Japan manufactured a Fourier-transform infrared spectroscopy instrument that produced the infrared spectra. The powdered ethanol extract obtained from two plant leaves was mixed with KBr pellet amounting to 100 milligrams through agate motor grinding of 10 milligrams extracts. The translucent pestle together with the sample disc served to transform the powdered substance.

GC–MS analysis of methanolic extract of *Foeniculum vulgare*

A split ratio of 1:20 operated during the sample feeding stage while giving the instrument 2 µl of extract substance. The testing process employed the "Perkin Elmer GC-MS coupled with Clarus 600 T mass Spectrometer (USA)" system. A gas chromatograph Clarus 600 operated as the core component by connecting it to a single quadrupole mass spectrometer while it operated with both an auto-injector device and an auto-sampler unit. The analysis of our processed samples was conducted through "TurboMass Solution Software Version 5.4" following GC-MS observations. Perkin Elmer, USA provided the Elite 5 MS capillary CG column for the separation process. The analytical procedure used helium as the carrier gas under constant pressure conditions amounting to 65.2 kPa. The separation procedure utilized a temperature gradient algorithm for its operation [11-13]. The temperature of the oven started at 40°C for 2 minutes before rising to 100°C at a rate of 5°C per minute for additional 2 minutes of heating. The temperature rose from 100°C at 5°C per minute up to 300°C while maintaining this level for five minutes. Kairomone was separated as the system operated for sixty-one consecutive minutes. Each unit of the mass spectrometer operated at the temperatures of 280 C for the injector then 240 C for the ion source and finally 220 C for the interface. The electron energy within the instrument was set at 70 electron volts. "The National Institute of Standard and Technology (NIST) Library version 2005" and the "Library from WILEY" tools served to determine the unknown ingredients.

Compound Identification

The separation of volatile compounds was identified through analogies between mass spectrometry results and database information compiled by the National Institute of Standard and Technology.

Singlet oxygen scavenging

The research team evaluated singlet oxygen (1O2) generation through spectrophotometric readings of N, N-dimethyl-4-nitrosoaniline (RNO) bleaching as reported in previous studies. The RNO bleaching reaction took place at 440 nm when singlet oxygen was generated through the NaOCl and H2O2 reaction. The reaction mixture consisting of 2 ml required 45 mM phosphate buffer (pH 7.1) along with 50 mM NaOCl and 50 mM H2O2 and 50 mM histidine and 10 μM RNO and sample amount of 0-200 μg/ml to reach the final solution. The RNO absorbance reduction was measured at 440 nm after the mixture incubated for 40 minutes at 30°C [14]. A comparison study between the sample and lipoic acid was performed to assess the sample scavenging activity. Each test was run six times.

Hypochlorous acid scavenging

Prior to the experimental start a solution of 10% NaOCl received a pH adjustment to 6.2 using 0.6 M H2SO4. The absorbance measurement at 235 nm enabled researchers to determine HOCl concentration using an molar extinction coefficient value of 100 M-1 cm-1. The experimental procedure adopted minor adjustments while keeping to the method defined by Aruoma and Halliwell. The scientist measured the scavenging activity through changes in 404 nm absorbance of catalase. The reaction solution contained 1 ml of pH 6.8 50 millimolar phosphate buffer with 7.2 micrograms of catalase and 8.4 millimolar hydrochloric acid together with plant extract amounts between 0 and 100 micrograms per milliliter. Experimental researchers analyzed the solution absorbance through a blank reference after allowing the reaction mixture to stand at 25°C for 20 minutes [15]. The tests operated at six repetitions for each procedure. Ascorbic acid served as the reference material in these tests since it functions well as a HOCl scavenger.

Statistical Analysis

The statistical analysis was conducted using SPSS version 19.0 (IBM, New York, NY, USA) to perform Tukey's honestly significant differences (HSD) test for mean value comparison at 95% or 99% confidence intervals after performing analysis of variance (ANOVA). A value of p less than 0.05 determined statistical significance during the analysis.

RESULTS AND DISCUSSION

A laboratory examination evaluated secondary metabolites in the aerial portions of Foeniculum vulgare that used ethanol as the extraction solvent. The therapeutic activities of pharmaceutical plants result mainly from phytochemical components such as steroids and tannins as well as terpenoids etc. Various biological activity effects exist for all recognized phytochemicals while antioxidant activity represents one possible action. These phytochemical compounds possess remarkable medicinal properties according to ancient as well as contemporary medical practices. Secondary metabolites act as the foundation for both medical and healing traits that plants possess. The ethanol aerial extract of Foeniculum vulgare contains several secondary metabolites such as flavonoids, tannins, saponins, steroids, terpenoids, and glycosides per prior phytochemical reports [16–19]. When you want to separate organic chemical components before identifying them by mass spectrometry you should work with a GC-MS chromatogram. The use of GC-MS analytical technique functions as an everyday confirmation method. Chemical testing programs achieve the highest benefits through its application. The analysis spectrum shows all substances which were extracted from the tested sample. Gas chromatography (GC) begins when the examination sample is inserted into its injection port. The GC apparatus functions to vaporize the sample before dividing its components into separate analyzable parts. Each high-quality part of the substance should have generated unique spectral peaks for digital recording on a paper chart. The Passage of time between when a substance begins its movement from the column and when the instrument receives it is known as retention time. The analysis of peaks by the National Institute of Standards and Technology (NIST) database [20, 21] included the measured peak range from base to tip when using more than 62,000 patterns. The spectra of known components at the NIST library undergo comparison operations with unknown component spectra. The identification of test materials components relied on three parameters which included their names together with chemical structures and molecular weights. The GCMS analysis of Foeniculum vulgare aerial plant parts in ethanol solution identified bio-active compounds through retention time, compound name, peak area and evaluation methods of its bioactivity according to this research. The biologically active compounds such as β-Pinene, pentadecanoic acid, γ-Terpinene, (R)-(-)-alpha-Phellandrene, Thymol, L-Fenchone, (-)-beta-Copaene, (E)-beta-ocimene, trans-Anethole, beta-Copaene, Dipentene, (E)-3,7-Dimethylocta-1,3,6-triene, oleic acid, n-Octadecane, Behenic acid, alpha-Linolenic acid, n-Capric acid, and palmitic acid. The traditional arabian medical practice utilized Foeniculum vulgare for treatment as a diuretic, appetizer, and digestive agent [20]. All parts of Foeniculum vulgare were used to add flavor to different culinary dishes with the leaves and seeds used as seasonings and the fruit and young leaves used independently for flavor creation. After purchase the young leaves either raw or cooked were employed in culinary preparation. The anise-like flavor emerges from the seeds

that food uses as seasoning. An agent used to relieve gas formed after boiling the fruits. The roots functioned as a purgative in medical practices. Breathing in crushed bananas served as an effective treatment for dizziness. The administration of fruit infusion acted as a treatment method for gas. Plaints collect their young plant shoots to serve two medical purposes: carminative treatment and respiratory condition therapy. The fruit juice served as a treatment to enhance eyesight. Consumers would drink decoction solutions both as eyewashes and breath fresheners and gargle with it. Fennel water represented aqua foeniculi which doctors prescribed for baby colic. Amenorrhea received treatment through drinking hot infusions made from roots and fruit according to medical records [21, 22]. A solution made from roots treated both toothaches and postpartum pain and postnatal pains during early childhood. The seeds were prepared as an infusion to relieve gas in infants. The medical treatment of urinary tract diseases included root-infused preparations. The application of oil served to treat both intestinal gas and worms. Medicinal beverages employed to lower body temperature contained fruit and nut pastes. The medicinal applications of seeds include serving as a stimulant and breast milk stimulant and having therapeutic properties for sexual illnesses alongside aid for childbirth and cough suppression and libido enhancement [23–25]. The assay of Foeniculum vulgare antioxidant capacity occurred through periodic observations of thiobarbituric acid and peroxide levels in the oil. The antioxidant features of the extract matched those of the volatile oil at similar capacity levels.

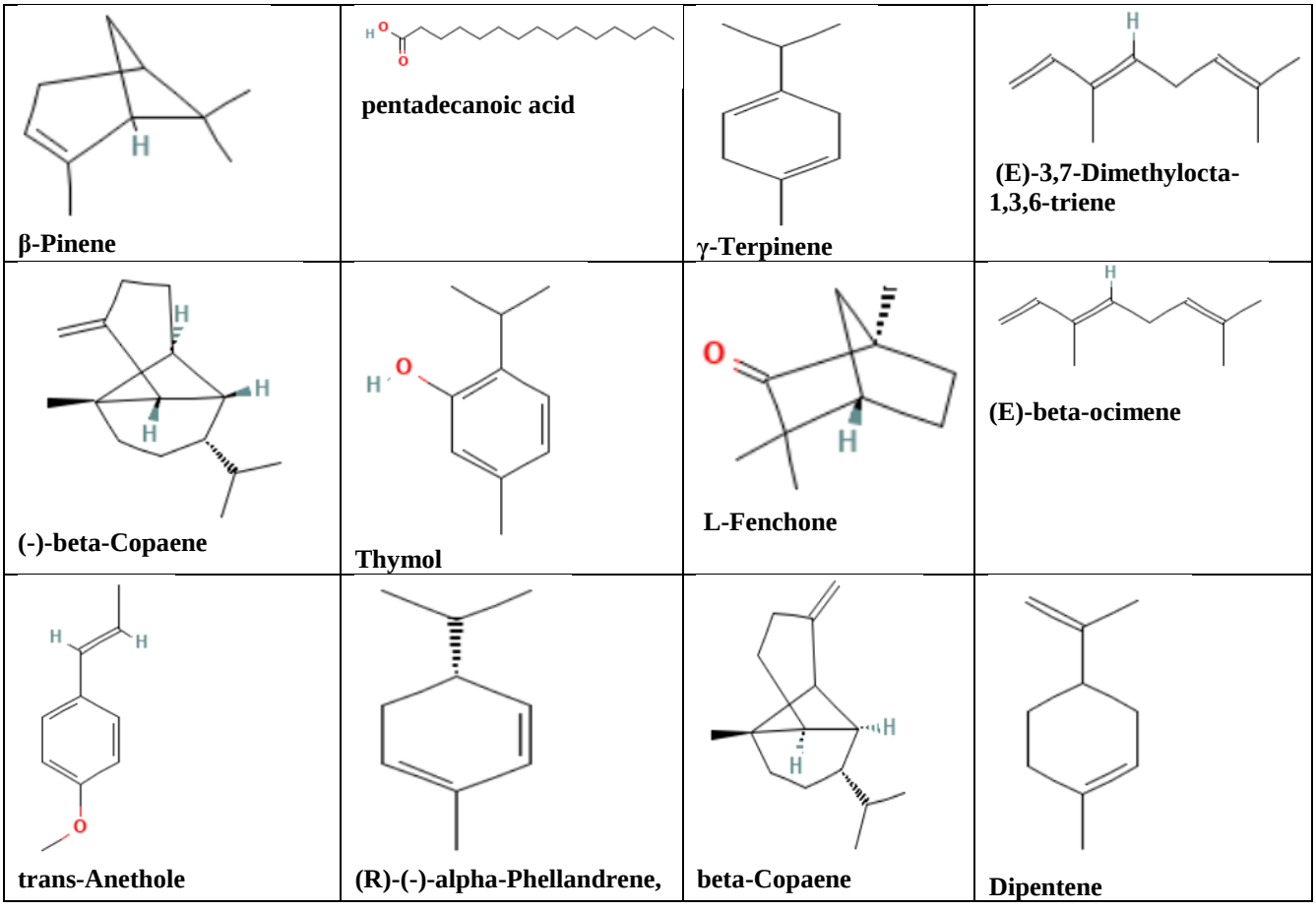
The Fourier Transform Infrared Spectrophotometer (FTIR) acts as an essential analytical instrument for identifying multiple functional groups found in chemicals. The FTIR analysis allows fast characterization of organic cells and precise determination of functional group frequencies through the observation of different vibration wave numbers. Fourier transform infrared spectroscopy serves as an analytical method to determine which functional groups in both plants carry therapeutic properties. The infrared spectra allow the detection of several different variations of basic inorganic materials. Multiple functional groups with distinctive attributes were detected through our analysis of various infrared frequency bands [26–29]. Table 1 shows that FTIR spectra revealed the existence of several functional groups, including alcohol (O-H group), carboxylic acid, amine, sulfur derivatives, amino acid, and nitro compounds. (667.37, 69.147, Strong, =C–H, Bending, Alkenes), (894.97, 82.045, Strong, =C–H, Bending, Alkenes), (1029.99, 61.548, Strong, C-F, Stretch, alkyl halides), (1238.30, 81.092, Strong, C-F, Stretch, alkyl halides), (1317.38, 81.874, Strong, C-F, Stretch, alkyl halides), (1373.32, 81. 514, Strong, C-F, Stretch, alkyl halides), (1519.91, 82.843, Medium, C=C, Stretch, Aromatic), (1616.35, 77.669, Bending, N-H, Stretch, Amide), (1743.65, 87.838, Strong, C=O, Stretch, Ester), (2852.72, 87.591, Strong, C-H, Stretch, Alkane), (2920.23, 83.176, Strong, C-H, Stretch, Alkane). When it comes to verifying the authenticity and legitimacy of food products, The public and private laboratory sector frequently utilizes FTIR spectroscopy as their screening instrument. The Fourier transform infrared spectroscopy (FTIR) functions as a prominent substitute against conventional analytical methods in sample assessment through its fast operation and minimal requirements for sample preparation and its ability to avoid sample destruction. The application of FTIR spectroscopy in edible oil and fat quantification studies has become increasingly popular to researchers [30]. Previous investigations indicated that the analysis of beef balls containing pork and juice concentration products can be accurately conducted through Fourier transform infrared spectroscopy. The device functioned to detect virgin oil adulteration in addition to its other analytical functions.

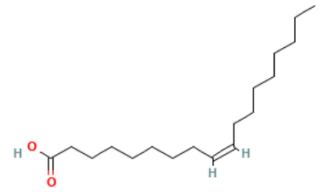
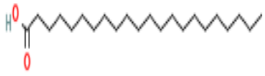
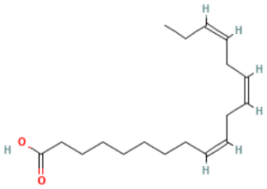
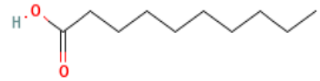
Rohman studied the application of Fourier transform infrared spectroscopy through chemometric methods to determine authentic meat and meat products. This technique has similar applications in identifying herbal foods and agricultural goods and dairy products alongside meat products. The test materials are filtered by infrared light as part of Fourier transform infrared (FTIR) analysis to determine their chemical characteristics. The chemical signature of the tested sample usually spans from 4000 cm−1 to 400 cm−1 and produces the observed detector signal spectrum. FTIR turns into a highly effective chemical identification technique because each substance and molecular structure generates its specific spectral pattern. A sufficient sample size for analysis requires small amounts and most examinations finish quickly after minimal sample preparation. The method offers both efficiency and simplicity as well as eliminates any requirement for preliminary sample handling. The non-destructive methods provide quick and dependable evaluation techniques for food items ranging from solids to liquids and pastes [31–33]. The testing procedures require less than five minutes to complete. Rohman was a scholar. Fourier transform infrared spectroscopy operates with various applications and specific boundaries. FTIR shows strong capability to detect a large spectrum of metabolite peaks while maintaining high speed and sensitivity in its operation. The system shows efficiency in data interpretation while providing simultaneous access to all frequencies related to metabolite observation. This gadget faces difficulties in examining water-based solutions because it cannot identify compounds having two symmetrical atoms including nitrogen and oxygen. The NMR device operating at 400 MHz frequency reports the spectral intensities together with frequencies at specific resonance peaks as ppm measurements. These spectral peaks serve to both identify and quantify the different components present in complicated mixtures without requiring extensive sample processing. During nuclear magnetic resonance (NMR) testing scientists avoid complex sample preparation steps because it provides the ability to detect multiple chemical species simultaneously [34, 35]. The NMR spectroscopy performs easily while resolving any possible compound combination and provides quantitative detection capabilities for every food constituent. Nuclear magnetic resonance (NMR) operates as a high-performance technique which demonstrates very responsive behavior. Chemical

assessments in such conditions prove to be difficult and dangerous due to both high costs and time-consuming procedures. NMR represents the most suitable technology for developing rapid assessment methods of non-target risks because of its limited sensitivity [36, 37]. The three nuclear tracers 2H (deuteron), 13C, and 15N function excellently to recognize rare nuclei. Modern research seeks various approaches to boost NMR sensitivity levels. Scientists develop NMR techniques through several methods including cold probe technology and use of hyperpolarization and tiny coils and superconducting coils and higher field magnets beyond 1.2 GHz. These affordable methods enhance detection sensitivity mostly for scarce biological compounds in the samples.

Table 1: GC–MS profile analysis of *Foeniculum vulgare*

Compounds	Molecular Formula	Molecular Weight
β-Pinene	C10H16	136.23 g/mol
pentadecanoic acid	C15H30O2	242.40 g/mol
γ-Terpinene	C10H16	136.23 g/mol
(R)-(-)-alpha-Phellandrene	C10H16	136.23 g/mol
Thymol	C10H14O	150.22 g/mol
L-Fenchone	C10H16O	152.23 g/mol
(-)-beta-Copaene	C15H24	204.35 g/mol
(E)-beta-ocimene	C10H16	136.23 g/mol
trans-Anethole	C10H12O	148.20 g/mol
beta-Copaene	C15H24	204.35 g/mol
Dipentene	C10H16	136.23 g/mol
(E)-3,7-Dimethylocta-1,3,6-triene	C10H16	136.23 g/mol
oleic acid	C18H34O2	282.5 g/mol
n-Octadecane	C18H38	254.5 g/mol
Behenic acid	C22H44O2	340.6 g/mol
alpha-Linolenic acid	C18H30O2	278.4 g/mol
n-Capric acid	C10H20O2	172.26 g/mol
palmitic acid	C16H32O2	256.42 g/mol



 **oleic acid**	 **n-Octadecane**	 **Behenic acid**	 **alpha-Linolenic acid**
 **n-Capric acid**			

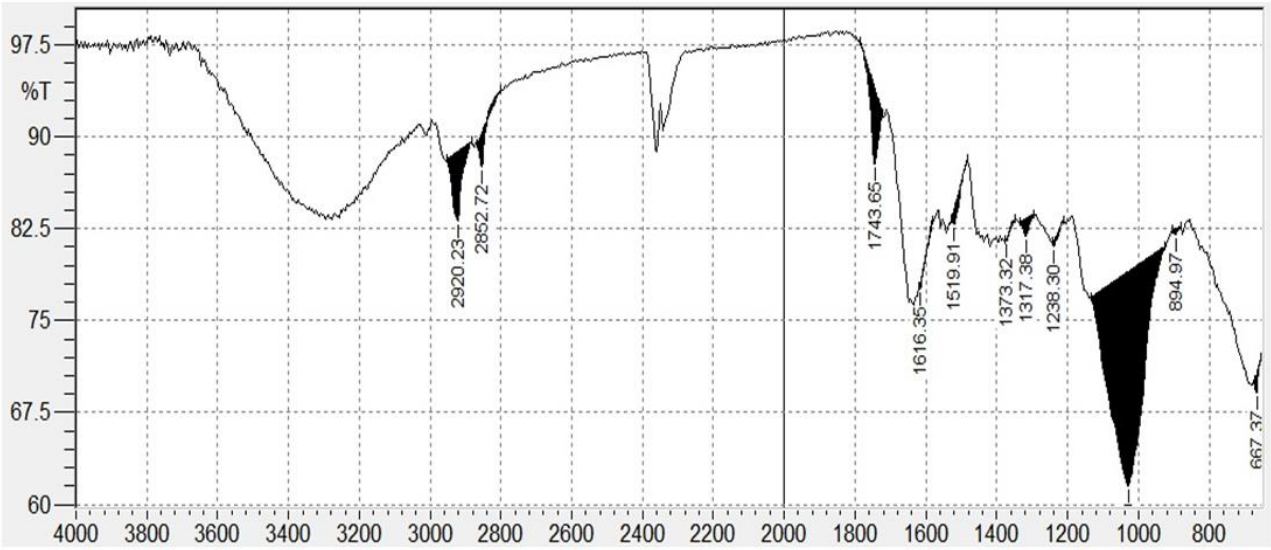


Figure 1. Fourier-transform infrared spectroscopic profile solid analysis of *Foeniculum vulgare*.

Table 2. FT-IR peak values of solid analysis of *Foeniculum vulgare*.

No.	Peak (Wave number cm^{-1})	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area	Type of Intensity	Bond	Type of Vibration	Functional group assignment	Group frequency
1.	667.37	69.147	1.522	673.16	653.87	2.915	0.063	Strong	=C–H	Bending	Alkenes	650-1000
2.	894.97	82.045	0.457	904.61	881.47	1.958	0.030	Strong	=C–H	Bending	Alkenes	650-1000
3.	1029.99	61.548	17.442	1134.14	925.83	32.156	10.810	Strong	C-F	Stretch	alkyl halides	1000-1400
4.	1238.30	81.092	0.518	1242.16	1211.30	2.645	0.042	Strong	C-F	Stretch	alkyl halides	1000-1400
5.	1317.38	81.874	1.459	1334.74	1296.16	3.182	0.136	Strong	C-F	Stretch	alkyl halides	1000-1400
6.	1373.32	81. 514	0.203	1375.25	1348.24	2.255	0.008	Strong	C-F	Stretch	alkyl halides	1000-1400
7.	1519.91	82.843	1.227	1527.62	1483.26	3.086	0.127	Medium	C=C	Stretch	Aromatic	1400-1600
8.	1616.35	77.669	0.321	1618.28	1579.70	3.636	0.027	Bending	N-H	Stretch	Amide	1550-1640
9.	1743.65	87.838	6.121	1786.08	1720.50	2.211	0.667	Strong	C=O	Stretch	Ester	1735-1750
10.	2852.72	87.591	2.845	2868.15	2802.57	2.629	0.191	Strong	C-H	Stretch	Alkane	2850-3000
11.	2920.23	83.176	5.651	2951.09	2883.58	4.259	0.812	Strong	C-H	Stretch	Alkane	2850-3000

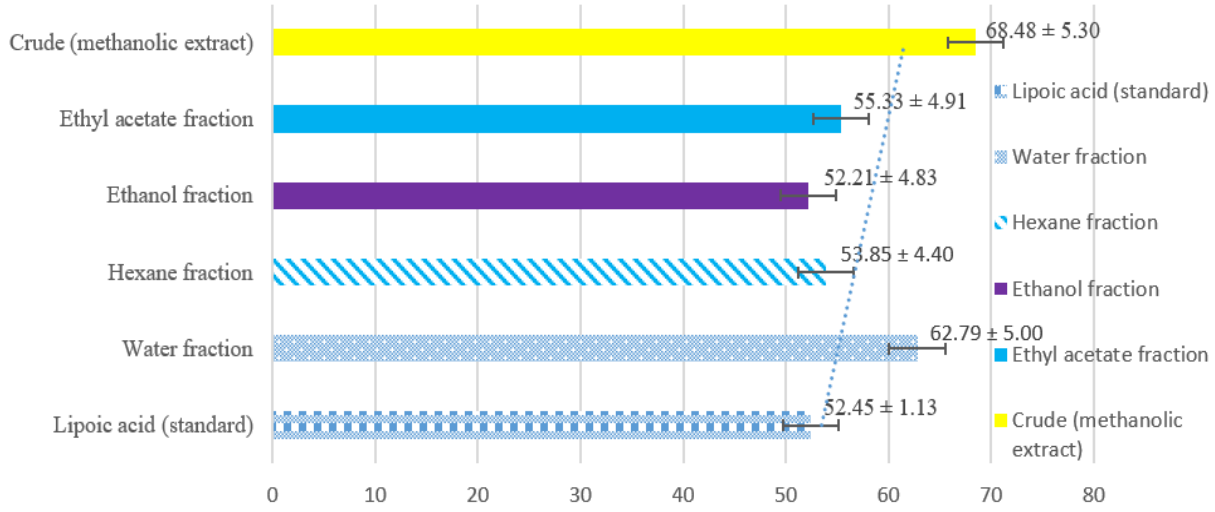


Figure 2. Antioxidant activity (Singlet oxygen scavenging) of leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Lipoic acid (standard)) of *Foeniculum vulgare*.

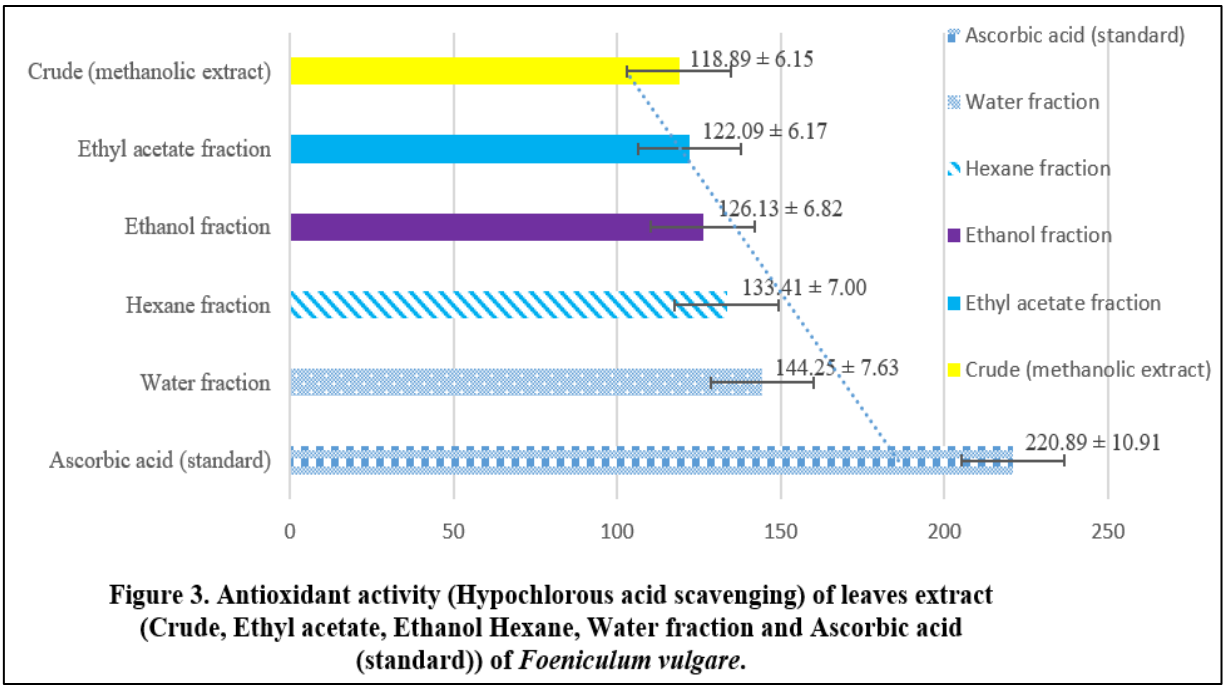


Figure 3. Antioxidant activity (Hypochlorous acid scavenging) of leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Ascorbic acid (standard)) of *Foeniculum vulgare*.

Antioxidant activity (Singlet oxygen scavenging) of leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Lipoic acid (standard)) of Foeniculum vulgare recorded 68.48 ± 5.30, 55.33 ± 4.91, 52.21 ± 4.83, 53.85 ± 4.40, 62.79 ± 5.00, and Lipoic acid (standard) 52.45 ± 1.13 respectively Figure 2. Antioxidant activity (Hypochlorous acid scavenging) of leaves extract (Crude, Ethyl acetate, Ethanol Hexane, Water fraction and Ascorbic acid (standard)) of Foeniculum vulgare recorded 118.89 ± 6.15, 122.09 ± 6.17, 126.13 ± 6.82, 133.41 ± 7.00, 144.25 ± 7.63, and Ascorbic acid (standard) 220.89 ± 10.91 respectively Figure 3. Prolonged radical production causing vessel constriction represents the main pathophysiological mechanism of septic shock damage to tissues. Inflammatory diseases that include ulcerative colitis and juvenile diabetes together with multiple sclerosis and arthritis and carcinomas manifest because of long-term nitric oxide radical expression. The toxicity level of peroxynitrite anion (ONOO-) becomes higher when superoxide radical combines with NO. Antioxidants delay and stop the oxidation of substances when they have lower concentrations than the substrates. Two main sources include endogenous antioxidant formation through processes such as superoxide dismutase synthesis and also exogenous antioxidant intake through diet. The traditional origin of exogenous antioxidants that exist in food comes from plant sources. Approximately sixty percent of plant species contain medicinal properties and antioxidants fill the majority of these medicinal species. Ascorbic acid extraction from plants generated interest

within the scientific community regarding additional exogenous plant antioxidants. After this period investigators intensely studied plants because plant antioxidants show promise for treating various serious medical conditions that start or progress because of elevated oxidative stress especially cardiovascular diseases and neurological conditions. The reduction of oxidative stress damage can possibly be achieved through strengthening natural antioxidant defenses in the body or through supplementation with external antioxidants. The measurement of antioxidant activity in plant samples usually requires one of nineteen in vitro tests or ten in vivo approaches. Most of the in vitro testing strategies revealed powerful antioxidant actions in plant samples [38]. Plants seem to naturally produce antioxidants together with phenolic compounds through their secondary metabolite metabolism. Laboratory tests have confirmed antioxidant properties in many plants but investigation of antioxidant effects within live animals exists only for a limited number of such plants. The assays that validate antioxidant activity within reaction systems during in vitro tests fail to show whether these findings can be extrapolated to actual living systems. A variety of phytochemicals have proved their antioxidant capabilities during laboratory testing. A limited number of drugs can serve therapeutic functions in vivo due to their disruption of processes related to absorption distribution metabolism storage and excretion of pharmaceutical substances [39, 40]. Laboratory experiments on phytochemicals as antioxidants continue to be studied in order to translate their findings into therapeutic uses. This fraudulent behavior challenges the medical usefulness and effective nature of plants used as external antioxidant resources.

CONCLUSION

Many researchers have analyzed the Foeniculum Vulgare leaves through aerial inspection by conducting GC-MS and FTIR analysis as well as phytochemical screening to study its phytochemical composition. Eleven medicinal bioactive chemicals appeared in the plant samples' ethanol extract based on GC-MS chromatographic analysis. Multiple secondary metabolites can be found in the ethanolic leaf extract of the sample according to phytochemical analysis. Folk remedies contain natural antioxidants which research shows that they hold potential for medical purposes. FTIR analysis detected various functional groups which displayed specific properties in the assessment. The examined chemical groups included amine nitrogen and O-H hydroxyl groups together with sulphur compounds. Future studies of Foeniculum vulgare leaves hold potential to discover more advantageous substances.

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