Journal of Research Administration
Society of Research Administrators International

SCREENING OF PHYTOCHEMICAL CONSTITUENTS IN *ILLICIUM VERUM* HOOK BY FTIR AND GCMS

Udaya Sri. P[1], Rajasekhar Pinnamaneni[2] and Leelavathi.V[1]
[1]Department of Biotechnology, Acharya Nagarjuna University, Nagarjunanagar- 522510, Guntur, Andhra Pradesh, India
[2]Department of Biotechnology, Koneru Laksmaiah Education Foundation, Vaddeswaram- 522302, Guntur District, Andhra Pradesh, India
*pudayasri@gmail.com

Abstract
Humans require secondary metabolites produced by medicinal plants. Spices are aromatic or strong-tasting phytochemicals of indigenous or alien origin are to enhance the flavour of foods, preserve food, and provide therapeutic benefits. The *Illicium verum* Hook is a popular culinary fruit having medicinal value with a high concentration of necessary and erratic oils. The fruit is exploited as a diuretic, anti-rheumatic, as well as a carminative, digestive, dyspepsia, anti-spasmodic, and stimulant. It also acts as an antifungal and antioxidant. FTIR and GCMS were used in the current work to investigate the star anise fruit extract. The current study's findings pave the door for further research into star anise fruits as a herbal remedy for a number of diseases.
Keywords: *Illicium verum*, Star anise, secondary metabolites, phytochemical analysis,

Introduction

The Chinese Pharmacopoeia lists the evergreen spice tree star anise (*Illicium verum* Hook) as an endemic species in southern China and northern Vietnam [1]. The aromatic, simple, lanceolate, elliptic, coriaceous leaves of star anise measure 5–15 cm x 2–5 cm. Flowers are solitary, bisexual, axillary, or subterminal, and their colors range from pink to dark crimson. Carpels are typically eight, free, and arranged in a single whorl; the perianth has seven to twelve spirally arranged lobes; the stamens have eleven to twenty spirally arranged lobes with short, thick filaments. There are seven to twelve broadly elliptic to broadly ovate tepals on the 1.5–4 cm–long flower peduncle. The pollen grains are trisyncolpate, and the panthers are 1-1.5 mm long. The fruit has eight to thirteen centrally linked carpels and is star-shaped, ranging in color from red to brown [1].

The powerfully scented star anise oil is used in skin care products, toothpaste, mouthwash, soaps, and cookery. All over the Indian subcontinent, it is used to make biryani and masala chai. It's a popular ingredient in Chinese, Malay, and Indonesian cooking. Anethole, the chemical that gives star anise its flavour, is also found in unrelated anise. Rheumatoid arthritis, stomach problems, skin inflammation, vomiting, and insomnia are all treated with star anise in traditional medicine. *Illicium* is used as a pharmaceutical supplement for its carminative, stomachic, stimulant, and diuretic effects [2]. Traditional Chinese medicine has long regarded Chinese star anise as a valuable therapy possessing antimicrobial properties [3, 4]. Antibacterial metabolites those are effective against *Acinetobacter baumannii* and *Staphylococcus aureus*, two pathogens of ESKAPE serious clinical diseases (*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii* and *Pseuinodom*) [5, 6]. It has been shown to have antioxidant properties and high anti-cancer potential [7, 8]. It is widely recognized for its application as a fragrant spice and in phytotherapy to alleviate respiratory cystitis and dyspeptic symptoms [9]. The common families of chemicals previously found in the plant include shikimic acid, seco-prezizaanetype sesquiterpenoids, phenylpropanoids, sesquilignans and flavonoids [1].

Star anise possesses antiviral, antifungal, antiseptic, insecticidal, and chemopreventive qualities[1]. Tamiflu, an antiviral medication containing a key ingredient shikimic acid is used to treat avian influenza [10]. Star anise is the primary source of shikimic acid, which is needed to make the pharmaceutical drug oseltamivir (Tamiflu) anti-influenza [1, 11, 12]. Up until recently, 90% of the world's annual star anise harvest was produced using shikimic acid, a chemical intermediate used to make oseltamivir, or Tamiflu. [13, 14]. To prevent quorum sensing and the formation of biofilms, star anise can be added to the food matrix [15]. Because star anise has therapeutic potential, this study concentrated on its FTIR and GCMS analysis.

Materials and Methods

Plant material

In September 2022, dried fruits of star anise (*Illicium verum*) were bought from a neighborhood market in Guntur, Andhra Pradesh, India. The plant material was ground into a powder following a thorough cleaning and three days of drying at 40°C in an oven.

Plant Material Extraction

20 grams of dry powder was taken in one hundred cubic centimeters of water free spirit for three consecutive days. All extracts were then diluted and analyzed using Whatmann paper No. 1. This process was repeated thrice. A crude extract was obtained by centrifuging the filtrates under vacuum and rotary evaporating them at 40°C. Following a 5-minute centrifugation at 10,000 rpm (7,000×g) for the extracts, the supernatant (approximately 2.7 mL) was incubated at -80°C. After drying, the extracts were put to use for analysis. Every chemical used was of the analytical/HPLC grade (Merck, India).

Measurement of the pH of the fruit extracts from *Illicium verum*

Using a pH meter label (ELICO), the pH of the binary mixture of the methanolic extract of star anise fruits was determined. To lower the level to 10 mg/ml, 1g of the binary compound of the methanolic extract of star anise fruits was dissolved in 100 cubic centimeters of water. To find the crude extract's hydrogen ion concentration, the pH meter electrode was submerged in the homogenized extract.

An examination of phytochemicals

To ascertain the presence of the following phytochemical compounds, such as phenols, flavonoids, alkaloids, carbohydrates, glycosides, tannins, and saponins, according to the quality protocol, fresh extracts were submitted to a basic phytochemical analysis [16, 17, 18].

Fourier transform infrared spectroscopy analysis

The extract's energy components can be rationally grouped by the FTIR spectrum, which also supports the extract's top quantitative relation regarding the location of Infra-Red radiation. FTIR analysis is accomplished using an Alfa-p-Bruker FT-IR prism spectroscope. After mixing two milligrams of leaf extract with two hundred milligrams of KBr (FT-IR grade), the mixture was compressed to create a salt disc with a diameter of three millimeters. Immediately after the disc was placed into the pattern holder, it broke free, and FT-IR spectra were obtained in the absorption region between 400 and 4000 cm^{-1}[19].

GC-MS Analysis

Gas chromatography-mass spectrometry (GC-MS) is a combination of two robust techniques to determine and measure substances with low detection limits. Ten grams of a tiny leaf sample are used to create the plant extract. The sample is diluted with thirty cubic centimeters of wood alcohol and filtered through two grams of small ash paper coated with sodium sulfate. Boiling chemical components concentrates plant growth extraction on the cubic centimeter and yields both polar and non-polar phytochemicals. For the GC-MS analysis, 2 µL of methanolic plant extract was utilized. Using an amalgamate silicon oxide column packed with 100% dimethyl polysiloxane, measuring 30 nm × 0.25 nm ID × 1µm df, the Clarus 500 Gas Chromatograph was employed for the analysis. Argonon was used as the carrier gas during the separation process, flowing continuously at a rate of 1 milliliter per minute. Once 2µl of the sample was injected into the column, the Perkin Elmer Turbo Gold Mass Detector and Turbo Mass 5.1 software were used to analyze the sample. In the 36th minute of the gigacycle per second extraction method, the kitchen appliance was maintained at 110°C for duration of two minutes. The temperature of the mass analyzer was adjusted to 250°C. 200°C for the supply temperature and 200°C for the inlet line temperature were the two completely different but jointly standardized operating parameters for the Clarus 500 MS. Thus, at 70 eV, fragments ranging in size from 45 to 450 daltons, and a scanning interval of 0.5 s were used to obtain the mass spectra. Therefore, it took 36 minutes to finish the MS detection process. Mass spectrometry in gigacycles and column retention time enabled fragment identification at the National Institute of Standards and Technology (NIST) library [20].

Results and Discussion

Phytochemicals are secondary metabolites of plant origin and make up all the substances mentioned in the body of the plant and concentrated in certain parts (active part of the plant) such as seeds, leaves, bark, stems, roots, flowers, fruits, etc. [21]. The health value of the plant consists of certain substances that have a very direct physiological effect on the human body. The most important biologically active compounds in plants are alkaloids, tannins, terpenoids, steroids and flavanoids [22].

FT-IR analysis

FT-IR analysis concluded the presence of different functional groups, including alcohols, phenols, carboxylic acids, alkanes, amines, primary and secondary amides, sulfones, sulfonyl chlorides, fluorides, ethers, esters, anhydrides, etc., (Figure 1; Table 1).

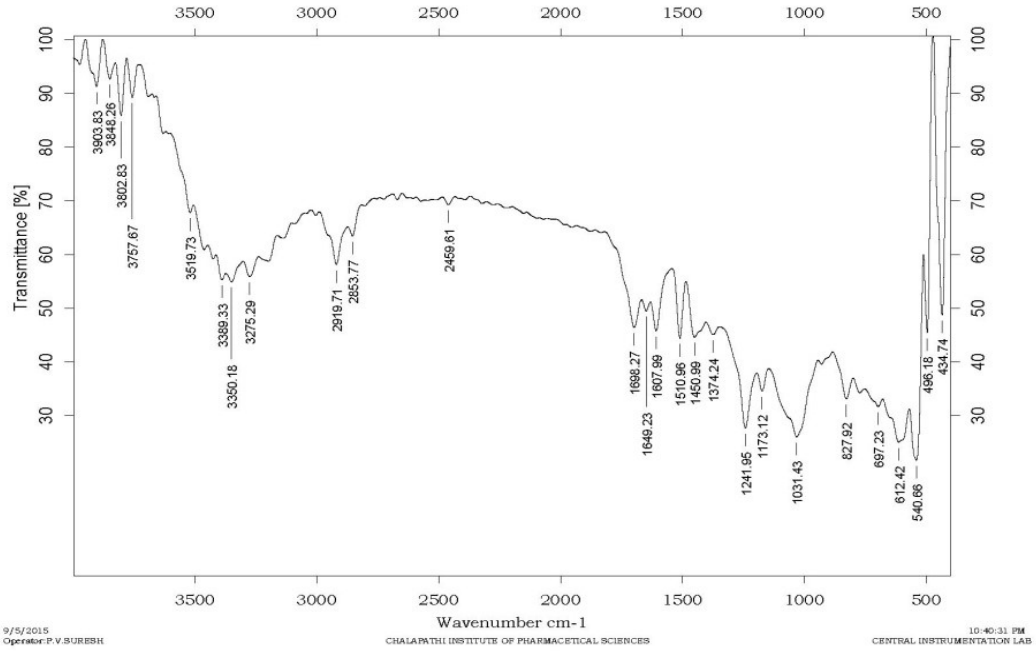

Fig.1: FTIR Spectrum of methanolic fruit extract of *Illicium verum*

Table 1: FTIR peak values and functional groups of methanolic fruit extract of *Illicium verum*

S. No.	Peak Value	Functional Group
1.	3519.73	NH_2 in aromatic amines, primary amines and amides
2.	3389.33	Alcohols, Phenols
3.	3350.18	Carboxylic acids
4.	3275.29	Primary and secondary amines and amides
5.	2919.71	alkanes
6.	2853.77	aldehyde
7.	2459.61	Carboxylic acid
8.	1649.99	Imines and oximes
9.	1607.99	Primary and secondary amines and amides
10.	1510.96	Nitro compounds
11.	1241.96	fluoride
12.	1173.12	Amines
13.	1031.43	Alcohols, ethers,esters, carboxylic acids, anhydrides
14.	827.92	Aromatic
15.	697.23	Alkenes
16.	612.42	Chlorides
17.	540.66	Bromide
18.	496.18	Iodide
19.	434.74	Bromide Iodide

GC-MS Analysis

Each component's relative value was ascertained by comparing the average peak area with the total area. To identify compounds, the NIST version 2.0-2005 library was utilized. The NIST database, which contains information on over 62,000 samples, was used to interpret the GC-MS peaks. The spectrum of the unknown component was compared to the spectrum of known components stored in the NIST library in order to ascertain the component's name, molecular weight, and composition in the test material. By using GC-MS to analyze the fruit extract of Illicium verum, 47 compounds were found. The results show the active principles of these compounds as well as their retention time (RT), peak position, mass charge ratio (M/Z), and SI values. (Fig.2; Table.2).

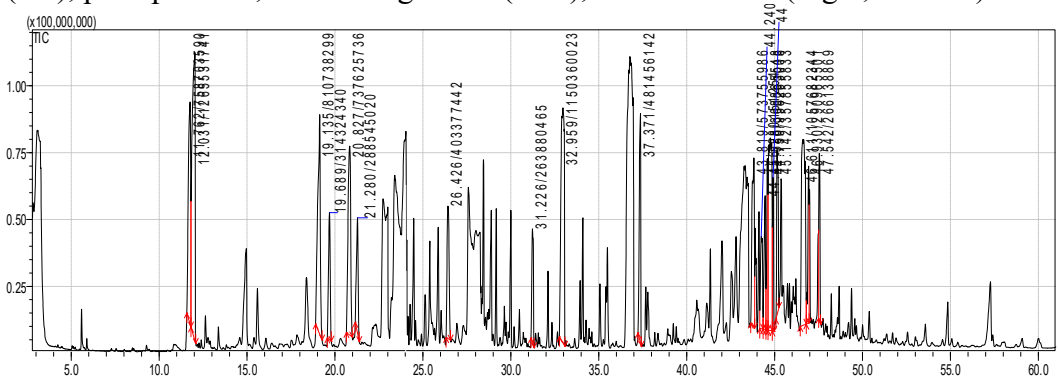

Fig.2: GC Chromatogram of *Illicium verum* fruit extract

Table.2: List of Compounds Identified in the Sample of *Illicium verum*

S. No	NAME OF THE COMPOUND	M/Z	RT	Area %	SI	M.wt	M.formula
1	d-Erythrotetrofuranose, tris-O-(trimethylsilyl)-	147	11.703	**3.97%**	85	336	$C_{13}H_{32}O_4Si_3$
2	Benzene, [3-(methoxymethoxy)-1-propenyl]-	148	11.987	2.72%	93	178	$C_{11}H_{14}O_2$
3	N-Methylrhodanine	147	12.635	1.22%	97	147	$C_4H_5NOS_2$
4	2,4,5,5,8a-Pentamethyl-6,7,8,8a-tetrahydro-5H-chromene	206	15.588	1.23%	97	206	$C_{14}H_{22}O$
5	Mercaptosuccinic acid, tris(trimethylsilyl) ester	73	18.387	5.08%	98	366	$C_{13}H_{30}O_4SSi_3$
6	Benzeneacetic acid, 4-methoxy-.alpha.-[(trimethylsilyl)oxy]-, methyl ester	135	19.108	2.51%	71	268	$C_{13}H_{20}O_4Si$
7	4.beta.H,5.alpha.-Eremophil-1(10)-ene, 11-(trimethylsiloxy)-	209	23.001	0.96%	94	294	$C_{18}H_{34}OSi$
8	1-Propene-1,2,3-tricarboxylic acid, tris(trimethylsilyl) ester, (Z)-	73	22.988	1.96%	97	390	$C_{15}H_{30}O_6Si_3$
9	3-Amino-3-(2,5-dimethyl-phenyl)-propionic acid	133	23.909	**3.70%**	88	193	$C_{11}H_{15}NO_2$
10	N-Methyl-2-hydroxy-4-phenyl-3-butenamide	133	24.029	1.02%	92	191	$C_{11}H_{13}NO_2$
11	Benzeneacetic acid, .alpha.,4-bis[(trimethylsilyl)oxy]-, trimethylsilyl ester	151	25.142	1.51%	91	384	$C_{17}H_{32}O_4Si_3$
12	2-Deoxy-galactopyranose, tetrakis(trimethylsilyl)	73	25.39	1.70%	98	452	$C_{18}H_{44}O_5Si_4$

13	4-Methoxyphenylpyruvic acid, bis(trimethylsilyl) deriv.	73	25.872	2.89%	98	338	$C_{16}H_{26}O_4Si_2$
14	Ribonic acid, 2,3,4,5-tetrakis-O-(trimethylsilyl)-, trimethylsilyl ester	73	26.429	5.42%	98	526	$C_{20}H_{50}O_6Si_5$
15	Glycoside, .alpha.-methyl-trtrakis-O-(trimethylsilyl)-	73	28.437	1.71%	96	482	$C_{19}H_{46}O_6Si_4$
16	1-(2,3-Dichlorophenyl)-1H-imidazole-2-thiol	209	28.888	**3.46%**	96	244	$C_9H_6CL_2N_2S$
17	D-Galactose, 2,3,4,5,6-pentakis-O-(trimethylsilyl)-	73	29.171	2.02%	98	540	$C_{21}H_{52}O_6Si_5$
18	Gulonic acid, 2,3,5,6-tetrakis-O-(trimethylsilyl)-, lactone	73	29.724	0.60%	94	466	$C_{18}H_{42}O_6Si_4$
19	Heptadecanoic acid, methyl ester	74	30.005	1.89%	97	284	$C_{18}H_{36}O_2$
20	2-Bromosebacic acid, bis(trimethylsilyl) ester	73	30.49	0.73%	98	424	$C_{16}H_{33}BrO_4Si_2$
21	3,4,5-Trihydroxybenzoic acid ethyl ester, tris(O-trimethylsilyl)-	73	31.226	3.69%	99	414	$C_{18}H_{34}O_5Si_3$
22	Galacturonic acid, pentakis(trimethylsilyl)-	73	31.412	0.25%	96	540	$C_{21}H_{52}O_6Si_5$
23	2-Phenyl[1,3]dithiane-2-carboxylic acid	73	32.117	1.49%	99	240	$C_{11}H_{12}O_2S_2$
24	Hexadecanoic acid, 3,7,11,15-tetramethyl-, trimethylsilyl ester	73	32.967	**4.32%**	96	462	$C_{21}H_{46}O_5Si_3$
25	Oleic Acid	55	34.094	0.85%	98	282	$C_{18}H_{34}O_2$
26	D-Fructose, 1,3,4,5,6-pentakis-O-(trimethylsilyl)-, O-methyloxime	73	35.073	1.42%	98	569	$C_{22}H_{55}NO_6Si_5$
27	8,11-Eicosadienoic acid, methyl ester	73	36.709	5.24%	95	322	$C_{21}H_{38}O_2$
28	13-Trimethylsilyloxy-9-octadecenoic acid, methyl ester	73	36.709	5.26%	88	384	$C_{22}H_{44}O_3Si$
29	Octadecanoic acid, dimethyl(isopropyl)silyl ester	73	37.371	**3.70%**	98	384	$C_{23}H_{48}O_2Si$
30	Dodecanoic acid, 2,3-bis(acetyloxy)propyl ester	73	37.68	0.81%	95	358	$C_{19}H_{34}O_6$
31	5-(4-tert-Butyl-benzylsulfanyl)-[1,3,4]thiadiazol-2-ylamine	148	37.788	1.73%	97	279	$C_{13}H_{17}N_3S_2$
32	(Adamantan-1-yl)acetic acid, (benzothiazol-2-yl)methyl ester	165	40.648	0.94%	89	341	$C_{20}H_{23}NO_2S$
33	Octadecanoic acid, 9,10-bis[(trimethylsilyl)oxy]-, methyl ester	73	41.349	1.12%	96	474	$C_{25}H_{54}O_4Si_2$
34	3H-Cycloocta[c]pyran-3-thione, 5,6,7,8,9,10-hexahydro-4-isopropyl-1-phenyl-	268	42.009	1.39%	95	312	$C_{20}H_{24}OS$
35	4-[N'-(3,5-Dimethyl-benzylidene)-hydrazino]-benzoic acid	268	42.537	0.71%	82	268	$C_{16}H_{16}N_2O_2$
36	2,4-Imidazolidinedione, 3-methyl-5,5-diphenyl-1-(trimethylsilyl)-	73	42.803	0.70%	86	338	$C_{19}H_{22}N_2O_2$ Si
37	L-Tyrosine, N,O-bis(tert-butyldimethylsilyl)-, tert-butyldimethylsilyl ester	73	44.108	2.09%	96	523	$C_{27}H_{53}NO_3Si_3$

38	1H-Indole-2,3-dione, 1-(tert-butyldimethylsilyl)-6-ethoxy-, 3-[O-(tert-butyldimethylsilyl)oxime]	73	44.296	1.36%	92	434	$C_{22}H_{38}N_2O_3Si_3$
39	3.beta.,17,21.alpha.-Tris(trimethylsiloxy)pregn-5-ene	73	44.108	2.09%	93	550	$C_{30}H_{58}O_3Si_3$
40	4-Methoxybenzenamide, N-(4-bromobenzylidenamino)-	135	44.585	2.61%	81	332	$C_{15}H_{13}BrN_2O_2$
41	Guaicol-.beta.-d-glucopyranoside, pentakis(O-trimethylsilyl)-	73	44.922	2.11%	93	574	$C_{25}H_{50}O_7Si4$
42	Hydroquinone-.beta.-tetrakis(O-trimethylsilyl)-d-glucopyranoside	73	45.177	**3.17%**	84	560	$C_{24}H_{48}O_7Si_4$
43	2-Monostearin trimethylsilyl ether	73	46.21	0.99%	93	502	$C_{27}H_{58}O_4Si_2$
44	1-Monolinoleoylglycerol trimethylsilyl ether	73	46.989	1.67%	94	498	$C_{27}H_{54}O_4Si_2$
45	Cholest-4-en-26-al, 3-oxo-, cyclic 26-(ethylene acetal)	73	50.382	0.49%	96	442	$C29H_{46}O_3$
46	Androstane-11,17-dione, 3-[(trimethylsilyl)oxy]-, 17-[O-(phenylmethyl)oxime], (3.alpha.,5.alpha.)-	73	54.846	1.16%	97	481	$C_{29}H_{43}NO_3Si$
47	2.beta.,3.beta.,14.alpha.-Tris(trimethylsilyloxy)-5.beta.-cholest-7-en-6-one	575	57.272	2.08%	96	648	$C_{36}H_{68}O_4Si_3$

Discussion

The functional group of the active compounds was analyzed on the basis of the peak value in the FTIR Spectrum 400–4000 nm range of infrared radiation. Using functional group analysis as a foundation, being highly sensitive, it is one of the dependable methods available for determining the chemical components and clarifying the structures of compounds used to detect the biomolecular composition. The crude extracts of the selected plant was subjected to FTIR analysis for the identification of functional constituents present in *Illicium verum*. The presence of distinct functional groups, which were identified based on the absorption spectra of different components, is revealed by the FTIR results. Its able to precisely determine the source of various extracts, effectively track down the constituents in the extracts, and recognize and assess the attributes of medicinal plant materials by utilizing the macroscopic fingerprint characters of the FT-IR spectrum. Therefore, one of the most reliable ways to authenticate and identify crude extract systems, like herbal medicine, is to use the FT-IR spectrum, which reflects the spectrum of chemical constituents in complex systems [24]. The results of the FTIR analysis show the peaks of the plant sample [24, 25]. These results also confirm that the selected plant extracts contain alcohols, phenols, carboxylic acid, alkanes, amines and amides, primary and secondary, sulfones, sufonyl chlorides, fluorides, ethers, esters, and anhydrides, among other compounds. The FTIR chromatogram of *Illicium verum* shows the major peaks at 3519.73, 3389.33, 3350.18, 3275.29, 2919.71, 2853.77, 2459.61, 1649.99, 1607.99, 1510.96, 1241.96, 1173.12, 1031.43, 827.92, 697.23, 612.42, 540.66, 496.18, 434.74nm respectively.

The methanolic extracts of the fruit of *Illicium verum* were further subjected to GCMS analysis. The results of the FTIR analysis show the peaks of the plant sample [24, 25]. These results also confirm that the selected plant extracts contain alcohols, phenols, carboxylic acid, alkanes, amines and amides, primary and secondary, sulfones, sufonyl chlorides, fluorides, ethers, esters, and

anhydrides, among other compounds. The mass spectrometer examines the type and structure of the chemicals to determine which ones are eluting at certain periods. The chromatograms of *Illicium verum* were displayed and the different components present in the extract have a complex chemical composition and the active principles of these extracts were presented along with their retention times (RT), peak areas and SI values and their Molecular formula and Molecular weight (MW). The large compound breaks down into smaller compounds, resulting in peaks with varying m/z ratios. These mass spectra are the fingerprints of that compound which can be identified from the data library. From the results it is evident that forty seven compounds were identified from the extract of *Illicium verum* and the presence of different compounds such as 2,4,5,5,8a-Pentamethyl-6,7,8,8a-tetrahydro-5H-chromene,2.beta.,3.beta.,14.alpha.-Tris(trimethylsilyloxy)-5.beta.-cholest-7-en-6-one, N-Methyl-2-hydroxy-4-phenyl-3-butenamide, Mercaptosuccinic acid, Benzeneacetic acid, 2-Deoxy-galactopyranose, tetrakis, Gulonic acid, 2,3,5,6-tetrakis-O-(trimethylsilyl)-, lactone, Heptadecanoic acid, methyl ester, D-Fructose, 1,3,4,5,6-pentakis-O-(trimethylsilyl)-, O-methyloxime etc. was revealed. These compounds were reported to show different biological activities such as Myo-neuro-stimulant, Neuroexcitant, Neoplastic, and NCS-Depressant, Anticancer (Oral), Antidote (organo-P), Antiretinitic Optometry, Antitumor (Ovary), Increase Osteocalcin. (Dr.Duke's Phytochemical and Ethanobotanical Database).

Previous research on the phytochemical analysis of Illicium verum reported 44 compounds, which is consistent with our findings [26]. According to the results of the current study, methanol's higher extraction capacity could have resulted in the production of more active constituents, which are in charge of a variety of biological activities and can be used to develop traditional medicines. [27, 28]. Chinese star anise consumption has resulted in intoxications due to adulterations of *I. verum* with the morphologically identical Japanese star anise (*I. anisatum* L.), which contains anisatin and other related toxic sesquiterpene lactones [29]. The scarcity raised questions about the quality of the remaining herbal material. Chemical analysis methods like TLC, HPLC-MS, and GC/MS [30, 31, 32] are extremely sensitive. Therefore, these plants have the potential to be a source of new phytopharmaceuticals. To develop a novel treatment for a number of incurable diseases, it will be necessary to isolate the corresponding bioactive compounds, characterize them, and conduct biological activity studies.

Conclusion

These studies were conducted for the analysis of methanolic extracts of the right fruit *I. verum* under FTIR, which can serve as a pharmacological indicator to analyze the medicinal value of *I. verum*. Working groups can be easily identified with this dynamic method, which is also cost-effective and simple. It is possible to forecast and contrast the phytochemical compounds present in this plant with those in other significant medicinal plants using the study's findings. Furthermore, biological compounds have to be separated so that their structures can be ascertained through sophisticated analytical methods like mass spectrometry and NMR.

Conflict of interest

There is no conflict of interest declared by the writers.

Author Contributions

The authors contribute equally throughout the text. All authors who participated in data analysis, writing, and revising the manuscript agreed with the journal to submit the manuscript, approved the final version for publication, and agreed to take responsibility for all aspects of the work.

References

1. Wang GW, Hu WT, Huang BK, Qin LP, 2011. *Illicium verum*: A review on its botany, traditional use, chemistry and pharmacology. J Ethnopharmacol. 136, 10-20.
2. Lee SW, Li G, Lee KS, Jung JS, Xu ML, Seo CS, Chang HW, Kim SK, Song DK, Son JK, 2003. Preventive agents against sepsis and new phenylpropanoid glucosides from the fruits of *Illicium verum*. Planta Med. 69, 861-864.
3. Singh G, Maurya S, de Lampasona MP, Catalan C, 2006. Chemical constituents, antimicrobial investigations and antioxidative potential of volatile oil and acetone extract of star anise fruits. J Sci Food Agric. 86, 111-121.
4. Yang JF, Yang CH, Chang HW, Yang CS, Wang SM, Hsieh MC, Chuang LY, 2010. Chemical composition and antibacterial activities of *Illicium verum* against antibiotic-resistant pathogens. J Med Food. 13, 1254-1262 .
5. Santajit S, Indrawattana N, 2016. Mechanisms of antimicrobial resistance in ESKAPE pathogens. BioMed Res Int. 2475067.
6. Salem MA, El-Shiekh RA, Hashem RA, Hassan M, 2021. In vivo antibacterial activity of star anise (*Illicium verum* Hook.) extract using murine MRSA skin infection model in relation to its metabolite profile. Infect Drug Resist. 14, 33-48.
7. Padmashree A, Roopa N, Semwal AD, Sharma GK, Agathian G, Bawa AS, 2007. Star anise (*Illicium verum*) and black caraway (*Carum nigrum*) as natural antioxidants. Food Chem. 104, 59-66.
8. Shu X, Liu XM, Fu CL, Liang QX, 2010. Extraction, characterization and antitumor effect of the polysaccharides from star anise *Illicium verum* (Hook f). J Med Plants Res. 4, 2666-2673.
9. Wichtl M, 2002. Anisi stellati Fructus – Sternanis. In: Teedrogen Und Phytopharmaka, 4th ed. *Stuttgart*: Wissenschaftliche Verlagsgesellschaft mbH. 45-47.
10. Ohira H, Torii N, Aida TM, Watanabe M, Smith RLJ, 2009. Rapid separation of shikimic acid from Chinese star anise *Illicium verum* (Hook f) with hot water extraction. Sep Purif Technol. 69, 102-108.
11. Bilal M, Wang S, Iqbal HMN, Zhao Y, Hu H, Wang W, Zhang X, 2018. Metabolic engineering strategies for enhanced shikimate biosynthesis: Current scenario and future developments. Appl Microbiol Biotechnol. 102, 7759-7773.
12. Sinha S, 2021. Oseltamivir (Tamiflu): Uses, dosage, side effects drugs.com. Cerner Multum, Inc. Version: 12.02.
13. Biba F, 2005. Sternanis und die Angst vor der Vogelgrippe. Öst Apoth Ztg. 59, 1239.
14. Schönholzer F, 2018. Dried stars. *UZH News*. Zurich: University of Zürich. Retrieved February 21st 2021.
15. Rahman MR, Lou Z, Zhang J, Yu F, Timilsena YP, Zhang C, Zhang Y, Bakry AM, Star A, 2017. Illicium verum (Hook. f.) as Quorum Sensing and Biofilm Formation Inhibitor on Foodborne Bacteria: Study in Milk. J Food Prot. 80, 645-653.
16. Varadharajan V, Janarthanan UK, Krishnamurthy V, 2012. Physicochemical, phytochemical screening and profiling of secondary metabolites of Annona squamosa leaf extract. World J Pharm Res. 1, 1143-1164.

17. Ali S, Khan MR, Irfanullah MS, Sajid M, Zahra Z, 2018. Phytochemical investigation and antimicrobial appraisal of *Parrotiopsis jacquemontiana* (Decne) Rehder. BMC Complement Altern Med. 18, 43.
18. Bolade OP, Akinsiku AA, Adeyemi AO, Williams AB, Benson NU, 2018. Dataset on phytochemical screening, FTIR and GC-MS characterisation of *Azadirachta indica* and *Cymbopogon citratus* as reducing and stabilising agents for nanoparticles synthesis. Data Brief. 20, 917-926.
19. Leelavathi V and Udaya Sri P, 2018. Analysis of Phytochemical constituents from the fruit extracts of *Illicium verum* Hook. J. Global Trends Pharm Sci. 9(2), 5476- 5485.
20. Anand T, Gokulakrishnan K, 2012. Phytochemical analysis of *Hybanthusennea spermus* using UV, FTIR and GC- MS, IOSR. J Pharm. 2, 520-524.
21. Criagg GM, David JN, 2001. Natural product drug discovery in the next millennium. J Pharm Biol. 39, 8-17.
22. Edeoga HO, Okwu DE, Mbaebie BO, 2005. Phytochemical constituents of some Nigerian medicinal plants. Afr J Biotechnol. 4, 685-688.
23. Lee KM, Jeon JY, Lee BJ, Lee H, Choi HK, 2017. Application of metabolomics to quality control of natural product derived medicines. Biomol Ther. 25, 559-568.
24. Oliveira RN, Mancini MC, Oliveira FCS, Passos TM, Quility B, Thiré RMS, Mcguiness GB, 2016. FTIR analysis and quantification of phenols and flavonoids of five commercially available plants extracts used in wound healing. Revista Matéria. 21, 767-779.
25. Rajiv P, Deepa A, Vanathi P, Vidhya D, 2017. Screening for Phytochemicals and FTIR Analysis of *Myristica dactyloids* Fruit Extracts. Int J Pharm Pharm Sci. 9, 315-318.
26. Wei L, Hua R, Li M, Huang Y, Li S, He Y, Shen Z, 2014. Chemical composition and biological activity of star anise *Illicium verum* extracts against maize weevil, *Sitophilus zeamais* adults. J Insect Sci. 14, 80.
27. Saravanakumar K, Raj A, Umaiyambigai D, 2016. GC-MS and FT-IR Profiling of leaves methanol extract from the *Pleiospermium alatum* (Wall. ex Wt. & Arn) Swingle Rutaceae family. J Phytopharmacol. 5, 201-204
28. Papitha R, Lokesh R, Kaviyarasi R, Bhuvaneswari M, 2016. Phytochemical screening, FT-IR and gas chromatography mass spectrometry analysis of *Tinospora cordifolia* (Thunb.) Miers. Int J Pharmacogn Phytochem Res. 8, 2020-2024.
29. Ize-Ludlow D, Ragone S, Bruck I, Bernstein J, Duchowny M, Garcia Peña B, 2004. Neurotoxicities in infants seen with the consumption of star anise tea. Pediatrics. 114, 653-656.
30. Schultze W, Zänglein A, Sternanis KK-H, Shikimi, der Früchte ZU von, 1990. *Illicium verum* HOOK. f. and *Illicium anisatum* L. Teil 2: Phytochemische Unterscheidungsmerkmale. Dtsch Apoth Ztg. 130, 1194-1201.
31. Lederer I, Schulzki G, Gross J, Steffen J, 2006. Combination of TLC and HPLC-MS/MS methods. Approach to a rational quality control of Chinese star anise. J Agric Food Chem. 54, 1970-1974.
32. Joshi V, Pullela VS, Khan IA, 2005. Rapid and easy identification of *Illicium verum* Hook. f. and its adulterant *Illicium anistum* Linn. by Flourescent microscopy and GC. J AOAC Int. 88, 703-706.