

ORIGINAL RESEARCH ARTICLE

Phytochemical, FT-IR and GC-MS analysis of bioactive compounds present in ethanolic extract of *Senna occidentalis* whole plant

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ABSTRACT

The increasing emergence of antimicrobial resistance has intensified the search for medicinal plants rich in bioactive compounds with therapeutic potential. *Senna occidentalis* is traditionally used in ethnomedicine due to its diverse phytochemicals. This study aimed to characterize the phytochemical constituents, functional groups and bioactive compounds in the ethanolic whole-plant extract of *S. occidentalis* using phytochemical screening, Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography–Mass Spectrometry (GC-MS). Whole plants were collected, authenticated and extracted with ethanol by cold maceration. The bioactive compounds present in the plant were analyzed using conventional phytochemical screening. Both FT-IR and GC-MS analyses were conducted following standard procedures at the Multi-user Laboratory of ABU, Zaria. A percentage yield of 11% was recorded. Qualitative phytochemical screening revealed the presence of alkaloids, flavonoids, tannins, phenolics, steroids, coumarins and other secondary metabolites. The FT-IR analysis yielded characteristic absorption bands linked to active functional groups. The broad band observed at 3330 cm^{-1} corresponded to O-H stretching vibrations linked with hydroxyl-containing compounds such as phenols. While medium absorption bands (2923 cm^{-1} and 2854 cm^{-1}) are attributed to terpenoids. A total of 67 peaks were identified via the GC-MS analysis. Nine of which were previously reported to possess antimicrobial activity. Oleic acid, Methyl palmitate, and 1,2-Octadecanediol were among the identified compounds and have been reported to exhibit antimicrobial, antioxidant, and anti-inflammatory activities. These findings demonstrate that *S. occidentalis* contains diverse bioactive phytochemicals and functional groups that may contribute to its reported medicinal properties and support its potential as a source of novel antimicrobial agents.

ARTICLE HISTORY

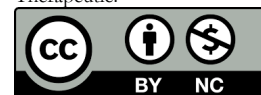
Received March 15, 2026

Accepted June 29, 2026

Published June 30, 2026

KEYWORDS

Antimicrobial, Bioactive, Coumarins, Maceration, Therapeutic.



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INTRODUCTION

Medicinal plants have recently gained greater prominence globally due to the rapid rise in antimicrobial resistance, serving an important role in providing safe, affordable healthcare worldwide, with use spanning all nations, ethnicities, and tribes (Abubakar *et al.*, 2020). In Certain ethnicities, plants are used as complements or substitutes for modern medical treatments because of the wide range of structural and biological diversity inherent in their phytochemicals. These phytochemicals confer immense antimicrobial activity against microbiological infectious agents (Wasihun *et al.*, 2023).

Several plant species produce both primary and secondary metabolites, which are regarded as their phytochemicals. These phytochemicals are known to possess strong antioxidant activities and exhibit antimicrobial, antidiarrheal, anthelmintic, antiallergic, antispasmodic, and antiviral activities. Some of them also aid in regulating gene transcription, improve immunity, and provide

protection against certain types of cancers (Kumar *et al.*, 2023).

On the list of widely used and globally accepted medicinal plants is *Senna occidentalis*, which is a spiny herb from the Family *Fabaceae*. The plant grows as a roadside shrub, either under shade or in the open (Rahman, 2023). *S. occidentalis* bears colourful green leaves, yellow flowers and seeds contained in pods that could measure up to 50 seeds per pod (Arvind *et al.*, 2024).

Locally *S. occidentalis* is commonly called Raidfore (Hausa), Asunwon Oyinbo (Yoruba), and Ogbolo (Igbo). *S. occidentalis* plant is known to be Autochthonous in many regions across the globe, including Nigeria; it is widely believed by folk medicine practitioners to bear a lot of antimicrobial activity against common pathogens due to its perceived vast array of phytochemicals. (Imon *et al.*, 2023)

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How to cite: Abduljalil, N. A., Olonitola, O. S., & Aliyu, M. S. (2026). Phytochemical, FT-IR and GC-MS analysis of bioactive compounds present in ethanolic extract of *Senna occidentalis* whole plant. *UMYU Scientifica*, 5(2), 380 – 387. <https://doi.org/10.56919/usci.2652.034>

The majority of pathogenic bacteria are increasingly developing mechanisms of resistance to commonly used antibiotics. This concerning rise in bacterial resistance to modern therapeutics is posing a life-threatening challenge to the public health sector, stretching it to the brink of collapse, especially in economically less developed nations (Moiketsi *et al.*, 2023). As a result of the stated reason above, there is a worldwide need and search for natural, affordable, less toxic, and safe antibacterial agents (Mráz *et al.*, 2025).

The phytochemical composition of *S. occidentalis* is numerous, including anthraquinones, flavonoids, triterpenoids, and other compounds such as essential oils and tannins. The quantity of these phytochemicals has been reported to vary with climatic conditions and geographic location. For example, plants from the Ivory Coast contain small amounts of saponins and no alkaloids, while those from Ethiopia have been found to contain large amounts of alkaloids in stems, leaves, and fruits (Shankar *et al.*, 2024).

Various parts of *S. occidentalis* have been studied, and their antimicrobial/biological activities have been documented. The crude extracts of the plant parts of *S. occidentalis*: leaves, seeds and pods have manifested antifungal activity against *Aspergillus clavatus*, *A. niger* and *Candida albicans*. The anthraquinones in its roots contain emodine, a promising experimental anticancer phytochemical (Amako *et al.*, 2023). The leaves of *S. occidentalis* were reported to contain a vast array of phytoconstituents, such as flavonoids, tannins, cardiac glycosides, alkaloids, steroids, and saponins, among others (Saminu and Na'ala., 2022). The whole plant of *S. occidentalis* has been reported by Abduljalil *et al.* (2026) to exhibit antibacterial activity against MDR-resistant *Salmonella* species due to its diverse array of phytochemicals.

Analysis of the FTIR spectrum of *S. occidentalis* has reported several oxygen- and carbon-based functional groups commonly associated with bioactive phytochemicals in plant extracts. These functional groups are typically associated with alcohols, esters, carboxylic acids, and phenolic compounds, which are known contributors to antimicrobial activity. Enols have also been identified by the broad H-bonded O-H stretch (Ganesan *et al.*, 2024; Audipudi *et al.*, 2020).

Gas chromatography-mass spectrometry of *S. occidentalis* detects numerous naturally occurring compounds with known biological/antimicrobial activity. Some of these compounds include *n*-hexadecanoic acid, linoleic acid, E-9-tetradecenoic acid, octadecanoic acid, 2-(2-hydroxyethoxy) ethyl esters, as 6-octadecenoic acid and hexadecanoic acid, 3-O-methyl-d-glucose and 13-docosenamide amongst others (Imon *et al.*, 2023; Amako *et al.*, 2023).

In light of the increasing global burden of antimicrobial resistance (AMR) and the need for a one-health approach to curb the growing menace. This study aims to investigate the phytochemicals present in the whole plant of *Senna occidentalis* in Zaria, Kaduna State. Although many

studies have been conducted on phytochemical screening of *S. occidentalis*, few have been conducted in the study area. Moreover, most studies focused on a particular part of the plant rather than the whole plant, despite the fact that traditional use of the plant sometimes points to using the whole plant as an herbal remedy. In addition, the majority of studies on *S. occidentalis* have focused primarily on preliminary phytochemical screening or on two combinations of FT-IR or GC-MS. Very few studies have integrated FT-IR and GC-MS analyses with phytochemical profiling to provide a comprehensive characterization of the plant's bioactive constituents. This fragmented approach limits a holistic understanding of its chemical composition and associated bioactivities. Therefore, the present study bridges this gap by combining phytochemical screening, FT-IR spectroscopy, and GC-MS analysis of the whole plant as potential antimicrobial/biological agents. There are a few researches conducted on *S. occidentalis* in Zaria, since the phytochemistry of the plants tend to vary with season, geographical area, climate conditions, Plants species, part of the plant, condition of the plant growth (Soil, water and temperature), and with the age of the plant (Chaudhury, 1999), hence, there is the need to evaluate the phytoconstituents as well as detect the functional groups through FT-IR and identify individual compounds via GC-MS analysis of *S. occidentalis* whole-plant grown in Zaria. Kaduna State.

MATERIALS AND METHODS

Plant collection

Whole plants of *Senna occidentalis* were collected locally in Zaria during the rainy season. The plants were taken to the Department of Botany, Ahmadu Bello University, Zaria for identification and authentication by Dr Namadi Sanusi, and a voucher specimen number was obtained (ABU01698) and used as a reference.

Preparation of Extracts

The authenticated, freshly collected whole plant was washed thoroughly with clean water and patted dry with a clean towel. A clean knife was used to cut the whole plant into smaller pieces, then spread on a clean tray and allowed to dry in the shade. The dried plant materials were ground into a fine powder using a mortar and pestle, and the powder obtained was stored in two separate, airtight glass containers. The containers were well labelled and kept for future use.

Plant Extraction

The powdered samples of *Senna occidentalis* plants were extracted using cold maceration as described by Mohammed *et al.* (2018). One hundred (100) grams of the powdered plant was weighed into a conical flask and sequentially mixed with 1000ml of ethanol. The solution was allowed to sit undisturbed for 24 hours before transferring to a shaker for 24 hours (cold maceration). A clean muslin cloth was used to filter the mixture. The filtrates were concentrated on a water bath at 45°C until all the ethanol was expelled out. The extract was scraped

off the dish and stored in a glass bottle until further use. The percentage yield of extract was calculated from respective weights of the extracts using the formula below.

$$\text{Percentage (\%)} \text{ yield} = \frac{\text{weight of extract}}{\text{weight of dry sample}} \times 100$$

Phytoconstituent analysis of whole-plant of *Senna occidentalis*

The phytochemicals examined in this study include alkaloids, flavonoids, tannins, saponins, phenols, glycosides, cardiac glycosides, terpenoids, steroids, anthraquinones, phlobatannins, and coumarins. In this procedure, two milliliters (2 mL) of the filtrate was poured into small test tubes and subjected to various phytochemical tests following the method described by Abduljalil *et al.* (2025) with slight modification.

Gas chromatography mass spectrometry (GC-MS) and Fourier Transform Infrared (FT-IR) analysis of the ethanolic extract of *S. occidentalis*

Both the FT-IR and GC-MS analyses were conducted at the Multi-user laboratory of the Department of Chemistry, Faculty of Physical Sciences, Ahmadu Bello University, Zaria. These procedures were conducted according to the method described by Keke *et al.* (2023).

Fourier Transform Infrared (FT-IR) analysis

Fourier Transform Infrared (Agilent Technologies) was conducted within the spectrum range 4000 cm⁻¹–650 cm⁻¹ with a resolution of 4 cm⁻¹, and 16 background scans across 32 scans. The instrument was switched on, calibrated, and allowed to warm up using the inert potassium bromide. Approximately 1 mL of *S. occidentalis* was placed in the FT-IR mortar, and an inert potassium bromide sample was added at a 1:50 ratio to the sample and ground to attain homogeneity. The mixture was then compressed with the FT-IR hand-press equipment to prepare a translucent pellet. The pellet was placed in the sample holder and mounted on the FT-IR machine, ready for analysis. The FT-IR spectrum of transmittance versus wavelength was obtained, and the interpretation yielded several pronounced peaks of interest.

Gas chromatography mass spectrometry analysis

The GC-MS machine was initially set to a GC oven temperature of 50 °C for post-run. The temperature was increased to 100 °C and held for 2 minutes; then the program temperature was set to increase at 10 °C/min until it reached 170 °C. No holding was assigned at this temperature; the temperature was finally allowed to increase to 280 °C at 5 °C/min. As individual constituents eluted from the GC column according to their volatility they entered the mass spectrometer, where they were ionized and fragmented into characteristic ions. The detector continuously recorded the ion signals, in which each peak represented a distinct chemical constituent. The retention time and peak area of each compound were automatically recorded by the instrument software. Identification of the detected compounds was achieved by

comparing the acquired mass spectra with those contained in the National Institute of Standards and Technology (NIST) integrated into the GC-MS software. Compound identification was done based on the highest spectral similarity (match quality), retention time, molecular ion pattern, and fragmentation profile.

RESULT

This research reported a yield of 11% of the ethanolic extract from whole-plant *S. occidentalis*. Thus:

$$\text{Extract yield} = \frac{11\text{g}}{100\text{g}} \times 100 = 11\%$$

Several bioactive compounds were detected in this study through the phytochemical tests conducted, among which are: alkaloids, flavonoids, tannins, phenolics, steroids, coumarins and other secondary metabolites (Table 1).

The Fourier Transform Infrared (FT-IR) spectrum of the whole-plant extract of *Senna occidentalis* yielded several characteristic absorption bands corresponding to diverse biologically active functional groups. The highest/broadest absorption band observed was at approximately 3330 cm⁻¹, indicating the presence of hydroxyl-containing compounds such as phenols, flavonoids, and tannins. The medium absorption bands at 2923 cm⁻¹ and 2854 cm⁻¹ were attributed to terpenoids, steroids, and other hydrocarbon-containing phytochemicals (Table 2; Figure 1).

GC-MS screening of the ethanolic extract indicated the presence of phytochemicals with varying antimicrobial/biological properties, including fatty acids, fatty acid esters, alkenes, alcohols, aldehydes, ethers, and other oxygenated organic compounds. A total of sixty-seven detectable peaks were observed at different retention times, but based on antimicrobial/biological activity only 9 are presented in this study, the other compounds identified in the peaks were not solely from naturally occurring phytochemicals but might emanated from derivatization artifacts, solvent residues, contaminants from the machine/laboratory environment, and instrument-related compounds, hence, they were excluded in the results (Table 3; Figure 2).

DISCUSSION

Phytochemical analysis of whole-plant extract of *S. occidentalis* revealed the presence of a vast array of bioactive compounds, amongst which are alkaloids, saponins, flavonoids, tannins, glycosides, coumarins and other secondary metabolites. These Plant-based phytoconstituents are well known for their diverse biological applications and antimicrobial properties. The pharmacological properties of these phytoconstituents include anti-diabetic, antioxidant, hepatoprotective, laxative, immunomodulatory, anti-pyretic, and fertility-enhancing activities. Flavonoids, for instance, are known for their antimicrobial, anti-inflammatory, and anti-ageing properties, while alkaloids have been reported to exhibit significant antimicrobial activity and to induce apoptosis in cancer cells, especially colon and breast cancer cells. Phenolic compounds in plants also serve as potent natural antioxidants.

Table 1: Phytoconstituent analysis of ethanolic extract of whole plant of *S. occidentalis*

Phytochemical Constituent	Test Conducted	Observation	Result
Alkaloids	Wagner's Test	Formation of reddish-brown precipitate	+
Flavonoids	Alkaline Reagent Test	Intense yellow color that disappears with acid addition	+
Tannins	Ferric Chloride Test	Blue-black or greenish-black coloration	+
Saponins	Frothing Test	Persistent honeycomb froth formation	+
Phenols	Ferric Chloride Test	Deep blue, green, or violet coloration	+
Glycosides	Keller-Killiani Test	Brown ring at the interface	+
C. Glycosides	Keller-Killiani Test	Reddish-brown ring below the interface	+
Terpenoids	Salkowski Test	Reddish-brown coloration at interface	+
Steroids	Liebermann-Burchard Test	Green or bluish-green coloration	+
Anthraquinones	Borntrager's Test	Pink, red/violet color in ammoniacal layer	+
Coumarins	Sodium Hydroxide Test	Yellow coloration	+
Phlobatannins	Hydrochloric Acid Test	Red precipitate formation	-

Key: C. Glycosides: Cardiac Glycosides, + = present, - = Absent

Table 2: Fourier Transform Infrared (FT-IR) absorption bands of *Senna occidentalis* whole-plant ethanolic extract

Peak (cm ⁻¹)	Functional Group	Probable Assignment	Possible Phytochemical Class
3330	O–H stretching	Alcohols/Phenols	Phenolics, flavonoids, tannins
2923	C–H stretching	Alkanes	Terpenoids, steroids
2854	C–H stretching	Aliphatic hydrocarbons	Lipids, terpenoids
1732	C=O stretching	Carbonyl compounds	Aldehydes, ketones, esters
1630	C=C stretching	Aromatic ring	Flavonoids, phenolics
1454	CH ₂ bending	Alkanes	Terpenoids
1383	CH ₃ bending	Methyl groups	Alkaloids, terpenoids
1318	C–N/C–O stretching	Aromatic amines or phenols	Alkaloids, glycosides
1245	C–O stretching	Phenolic ethers	Flavonoids
1162	C–O stretching	Secondary alcohol	Glycosides
1112	C–O stretching	Alcohols	Carbohydrates
1035	C–O stretching	Primary alcohol	Sugars and glycosides
898	Aromatic C–H bending	Aromatic compounds	Polyphenols
824	Aromatic C–H bending	Benzene derivatives	Aromatic metabolites
760	Aromatic ring deformation	Substituted benzene	Phenolics
697	Aromatic ring deformation	Benzene derivatives	Aromatic phytochemicals

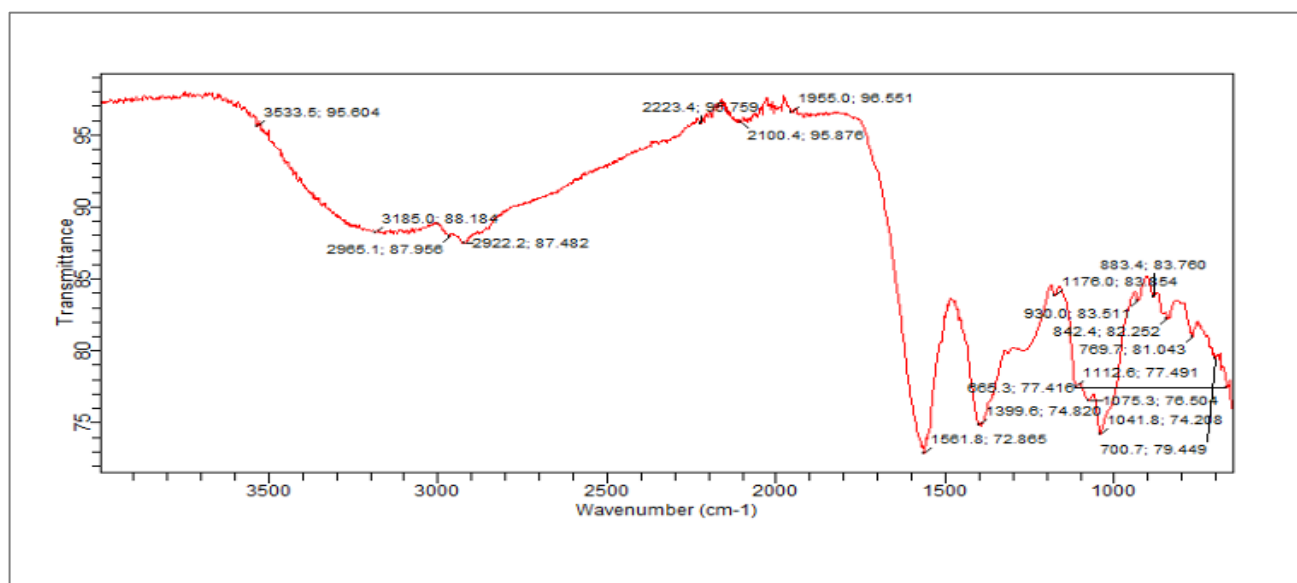


Figure 1: FT-IR Spectrum of the ethanolic extract of *Senna occidentalis* whole-plant

Table 3: GC-MS analysis of some of the bioactive compounds detected from *S. occidentalis* whole-plant

Priority	Peak	RT (min)	Compound	Molecular Formula	Area (%)	Quality (%)	Chemical Class	Confidence	Reported Biological Activities
1	2	5.251	Decanoic acid, ethyl ester	C ₁₂ H ₂₄ O ₂	8.01	92	Fatty acid ester	Confirmed natural phytochemical (High confidence)	Antibacterial, antifungal, antioxidant, membrane-active lipid
2	12	14.651	9-Octadecenoic acid (Oleic acid)	C ₁₈ H ₃₄ O ₂	2.17	64	Unsaturated fatty acid	Confirmed natural phytochemical (High confidence)	Antibacterial, anti-inflammatory, antioxidant, cardioprotective
3	20	24.286	Oleic acid	C ₁₈ H ₃₄ O ₂	1.93	68	Unsaturated fatty acid	Confirmed natural phytochemical (High confidence)	Membrane disruption, antibacterial, antioxidant
4	9	12.034	Hexadecanoic acid, methyl ester (Methyl palmitate)	C ₁₇ H ₃₄ O ₂	1.51	46	Fatty acid methyl ester	Confirmed natural phytochemical (Moderate confidence)	Antibacterial, antioxidant, anti-inflammatory
5	6	10.148	1,2-Octadecanediol	C ₁₈ H ₃₈ O ₂	2.39	81	Fatty alcohol	Confirmed natural phytochemical (High confidence)	Antimicrobial, emollient, membrane-active lipid
6	3	7.739	1-Heptadecene	C ₁₇ H ₃₄	3.23	90	Long-chain alkene	Probable natural phytochemical	Antimicrobial, insecticidal, hydrophobic lipid
7	8	10.798	1-Dodecanol, 2-hexyl-	C ₁₈ H ₃₈ O	0.59	38	Fatty alcohol	Probable natural phytochemical	Antimicrobial, surfactant, membrane-active compound
8	15	15.7	Heptadecanoic acid, heptadecyl ester	C ₃₄ H ₆₈ O ₂	1.55	43	Fatty acid ester	Probable natural phytochemical	Lipid ester with reported antimicrobial activity
9	19	24.158	Oxacyclotetradecan e-2,11-dione, 13-methyl-	C ₁₄ H ₂₄ O ₃	0.52	25	Macrocyclic lactone	Tentative identification	Macrocyclic compound reported in some natural products

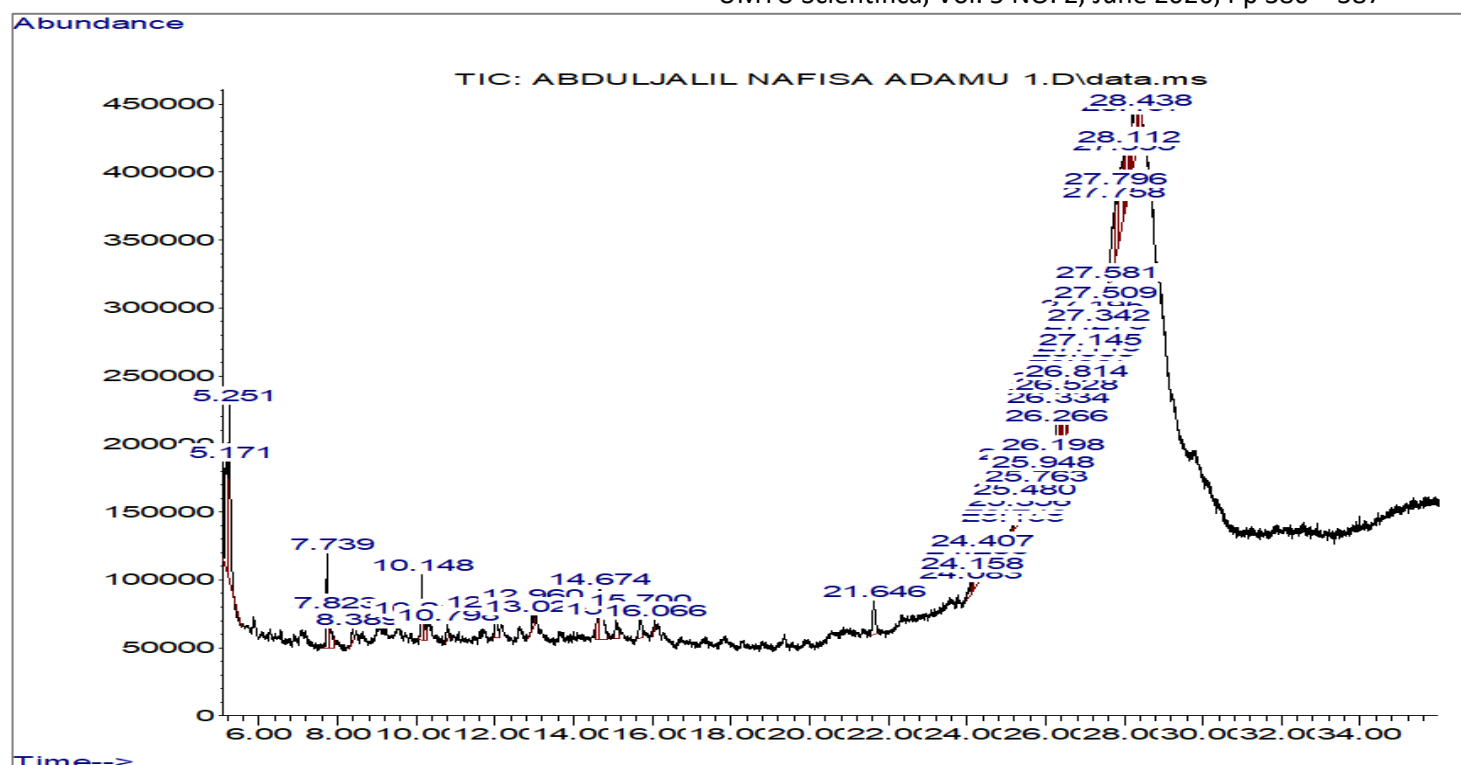


Figure 2: GC-MS Spectra of ethanolic extract of *S. occidentalis* whole-plant

The findings of the present study are consistent with those of Imon *et al.* (2023), who reported the presence of similar phytochemical constituents in both ethanolic and methanolic leaf extracts of *S. occidentalis*. The roots of this plant are known to contain biologically active components such as terpenoids, flavonoids, emodin, and other secondary metabolites, most of which are known for both antibacterial and antifungal abilities, as reported in the research of Bharti *et al.* (2024). Abduljalil *et al.* (2026) also reported similar phytochemicals in the whole plant extracts of *Cassia occidentalis*. This confirms that these bioactive compounds are consistently distributed throughout different parts of the plant, although minor variations in phytochemical composition may occur due to differences in geographical origin, climatic conditions, plant maturity, harvesting season, extraction solvent, and analytical methods employed.

The Fourier Transform Infrared (FT-IR) vibration spectroscopy of *S. occidentalis* also detected a vast array of chemical bonds/functional groups, the spectra revealed a total of 16 peaks within the spectra range of (330 to 697 cm^{-1}) with each of the peaks hinting to a particular functional group corresponding to a number of functional groups. Specifically, O-H stretching vibrations are typical of alcohols/phenolic compounds which are well documented for their antimicrobial and anti-oxidant effect through free-radical scavenging and disruption of cell membranes of microorganisms. The presence of C-H bonds is indicative of the presence of terpenoids and steroids, which are known to exert antibacterial activity by disrupting the integrity of bacterial cell membranes. The stronger C=C bonds identified indicate the presence of an aromatic ring, which is mostly found in flavonoids and phenolics. These compounds are known to inhibit bacterial enzymes, interfere with DNA synthesis, and

reduce biofilm production in certain microorganisms. Several C-O and aromatic C-H bonds were detected at varying peaks. Comparable findings have been reported by Arora (2014), who documented FT-IR spectral peaks in both Root and stem tissues, with strong peaks in the 500-1000 cm^{-1} range, indicating functional groups such as C-H, C-O, and C=C. In contrast, Sayed *et al.* (2023) reported significant peaks in the FTIR bands observed in the region 1000–1500 cm^{-1} , which can be indexed to the O=C=O symmetric and asymmetric stretching modes and the C–O stretching vibration. The current study differs from the study conducted in Bangladesh by Imon *et al.* (2023), which showed FT-IR peaks at 3700–3000 cm^{-1} in the ethanolic leaf extract of the plant; the broad band functional groups identified in that study include Carboxylic acids (O-H) and aromatic alkene (C=C).

Analysis of the GC-MS spectral profile and retention times confirmed the presence of key components. The Peak heights highlighted the concentration of the extract's components. A total of 67 peaks were identified in this analysis, 9 of which were found to be naturally occurring antimicrobial agents based on already documented literature. The highest and most abundant compound identified is Decanoic acid, ethyl ester (ethyl decanoate) which is known to bear antibacterial, antifungal and antioxidant effect due to its membrane-active lipid binding ability. Subsequently, Oleic acid /Methyl palmitate, and 1,2-Octadecanediol were identified as the next abundant compounds in *S. occidentalis* whole plant, these compounds are known to exert significant antimicrobial efficacy against microorganisms as well as anti-oxidant and anti-inflammatory effect. The findings of this study are consistent with those of Audipudi *et al.* (2020), who reported the presence of 8 compounds in their GC-MS analysis, with octadecanoic acid as the most abundant and

prominent compound among the 8 compounds detected in the chloroform leaf extract of *S. occidentalis*. In another complimentary analytical study conducted by Ibrahim *et al.* (2026), the LC–MS analysis revealed a chemically diverse profile, primarily identifying taxifolin, 6"-O-p-coumaroyltrifolin, aloe-emodin, and 6-hydroxynicotinic acid. The detection of aloe-emodin, while other reported compounds were absent, aligns this finding with the current study.

The current findings are also in accordance with those reported by Amako *et al.* (2023) and Ganesan *et al.* (2024), who identified several components similar to those reported in the current research, namely, n-hexadecanoic acid, linoleic acid, E-9-tetradecenoic acid, octadecanoic acid, and ethyl ester, among others. Detection of these compounds strongly indicates that the characteristic constituents of *Senna occidentalis* may contribute to its reported antimicrobial/biological activities.

CONCLUSION

The Phytochemical, GC-MS, and FT-IR analysis of the ethanolic extract of *S. occidentalis* whole plant in this study revealed a vast array of biological and antimicrobial compounds identified as antimicrobial, antioxidant, and anti-inflammatory agents. Chemical bonds detected by FT-IR also provided strong evidence for the abundant bioactive compounds in this plant, as 16 peaks were recorded and corresponded to the plant's inherent bioactive compounds. A total of 9 naturally occurring bioactive compounds were identified through GC-MS analysis, all of which are directly linked to the wide range of biological and therapeutic efficacy of *S. occidentalis* and, in turn, offer substantive proof of the plant's use in traditional medicine.

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