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## Research Article

# GC-MS Analysis on the Methanolic Leaves, Stem and Root Extract of *Hyptis suaveolens*

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### ABSTRACT

Phytochemical profiling of medicinal plants provides critical insights into their chemical composition and supports the scientific validation of ethnomedicinal applications. *Hyptis suaveolens*, a member of the *Lamiaceae*, is widely utilized in traditional medicine for the management of infections, fever, and malaria. The present study aimed to characterize the chemical constituents of the methanolic extracts of leaves, stem, and root of *H. suaveolens* using Gas Chromatography–Mass Spectrometry. *Hyptis suaveolens* were collected, authenticated, shade-dried, pulverized, and extracted with methanol using standard procedures. The resulting extracts were subjected to GC–MS analysis employing an Agilent 7890 gas chromatograph coupled with a 5975-mass selective detector. Compound identification was achieved by comparison of mass spectra with reference library databases. The chromatographic analysis revealed a diverse array of phytochemical classes, including fatty acids, methyl esters, phenolic compounds, heterocyclic derivatives, hydrocarbons, and terpenoid-related compounds. Predominant constituents in the leaf extract included 1-dodecanol, 2-methyl-, (S)- (23.592%), 7-oxabicyclo [4.1.0] heptane, 1,5-dimethyl- (17.235%), and 9,17-octadecadienal (14.404%). The stem extract was characterized by relatively high proportions of 5-vinyl-pyrazole (20.723%) and 3-cyclopentyl-1-propyne (19.793%). In the root extract, cis-vaccenic acid (37.05%), 9-octadecenoic acid (Z)-, methyl ester (13.25%), and n-hexadecanoic acid (12.71%) were the major detected compounds. This study provides a comprehensive chemical profile of different parts of *H. suaveolens*. The findings establish baseline phytochemical data that may guide future bioassay directed investigations. However, the present work is limited to chemical characterization, and no biological activity is inferred from the GC–MS data alone.

**Keywords:** Extract; GC–MS; *Hyptis suaveolens*; Methanol; Phytochemicals

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### INTRODUCTION

The phytochemical investigation of medicinal plants remains fundamental to understanding their chemical diversity and supporting their traditional applications. *Hyptis suaveolens* (L.) Poit., commonly referred to as bush mint, is widely distributed across tropical and subtropical regions and is extensively utilized in ethnomedicine for the management of febrile illnesses, infections, gastrointestinal disorders,

and inflammatory conditions. Previous studies have reported the presence of diverse classes of secondary metabolites in *H. suaveolens*, including flavonoids, alkaloids, saponins, tannins, terpenoids, and phenolic compounds (Amaka *et al.*, 2018; Ghaffari *et al.*, 2014). In addition, essential oil analyses and preliminary phytochemical screenings have demonstrated variability in chemical constituents depending on

geographical origin, extraction solvent, and plant part examined (Mishra *et al.*, 2021).

Despite these contributions, several limitations remain evident in the existing literature. First, many studies have focused predominantly on essential oils or single plant parts most commonly the leaves while comprehensive comparative profiling of leaves, stem, and root extracts within the same experimental framework remains limited. Second, variations in ecological conditions and geographic location have been shown to influence secondary metabolite composition, yet region-specific chemical data are still insufficient for many populations of *H. suaveolens* (Starlin *et al.*, 2019). Furthermore, earlier reports often relied on preliminary phytochemical screening methods that provide only broad metabolite classification without detailed compound-level identification. (Xu *et al.*, 2021).

Gas Chromatography–Mass Spectrometry (GC–MS) is an established analytical technique for the characterization of volatile and semi-volatile constituents in complex plant extracts and enables reliable compound identification through spectral library matching. However, systematic GC–MS-based comparative profiling of multiple anatomical parts of *H. suaveolens* collected from this geographical region has not been adequately documented.

Therefore, the present study aims to provide a detailed GC–MS characterization of methanolic extracts of the leaves, stem, and root of *H. suaveolens* collected from the study area. By conducting a multi-part comparative analysis under uniform experimental conditions, this work seeks to generate region specific phytochemical data and address the existing gap in comprehensive chemical profiling of different plant organs.

## **MATERIALS AND METHODS**

### **Collection of Plant Sample**

The plant *Hyptis suaveolens* was identified and authenticated by the Department of Plant Bioresources, Bioresource Development Centre, National Biotechnology Development Agency, Nigeria. A voucher specimen was prepared and deposited at the herbarium of the Department of Plant Bioresources, Bioresource Development Centre, NABDA, with voucher specimen number NABDA/BDC/PBR/2024/019.

### **Preparation of Methanolic Extract**

20g sample of powdered sample were soaked in 200mL of methanol for 72 hours with periodic shaking. After soaking, the mixture was filtered using Whatman No. 1 filter paper, and the methanol was evaporated under reduced pressure using a rotary evaporator to obtain the methanolic extract.

### **Gas Chromatography-Mass spectrometry (GC-MS) Analysis**

GC–MS analysis of the methanolic extracts of *Hyptis suaveolens* was performed at the Yobe State University Chemistry Analytical Laboratory using an Agilent 7890A gas chromatograph coupled to a 5975C mass selective detector with an HP-5MS capillary column (30 m × 0.320 mm × 0.25 μm). Helium (1 mL/min) served as the carrier gas, and 1 μL of each extract was injected in splitless mode with the injector at 250°C. The oven temperature was programmed from 80°C (2 min hold) to 240°C at 12°C/min and held for 6 min. Mass spectra were acquired under electron ionization at 70 eV, with the source at 230°C and interface at 250°C over an m/z range of 50–500. Compound identification was performed using the NIST 14 spectral library, considering only matches with a similarity index ≥80%, and retention times were cross-checked with literature data to ensure reliability and reproducibility.

## **RESULTS**

### **Leaves Extract**

Among the compounds identified in the leaves extract as shown in Table 1, 1-dodecanol, 2-methyl-, (S)- exhibited the highest relative abundance (23.592%), indicating that it constitutes a major component of the leaves extract. This was followed by 7-oxabicyclo-[4.1.0]-heptane, 1,5-dimethyl- (17.235%) and 9,17-octadecadienal (Z) (14.404%), suggesting a significant contribution of bicyclic compounds and unsaturated aldehydes to the phytochemical composition of the leaves. In addition, hexadecanoic acid methyl ester was present at a notable level (11.517%), indicating the occurrence of fatty acid derivatives in the extract. Other compounds were detected in moderate to minor proportions, including heptadecanoic acid, 16-methyl-, methyl ester (5.244%), 2-decen-1-ol (E) (4.781%), and undec-10-ynoic acid esters with relative abundance. heneicosane and 1-docosene, as well as the phenolic

compound phenol, 2,5-bis(1,1-dimethylethyl), were also identified but occurred in relatively lower concentrations.

**Stem Extract**

Table 2 presents the phytochemical constituents detected in the methanolic stem extract of *Hyptis suaveolens*. The chromatographic profile indicates that 5-vinyl-pyrazole was the most abundant compound, with the highest percentage area (20.723%) at a retention time of 16.405 min. Another peak corresponding to the same compound was detected earlier (9.861 min) with a relative abundance of 7.491%, suggesting possible structural isomerism. The second most abundant compound was 3-cyclopentyl-1-propyne (19.793%). Propanedinitrile, methylene also exhibited a relatively high abundance (15.278%), highlighting the presence of nitrile derivatives in the stem extract. Others compounds were also detected in appreciable quantities, particularly acetic acid, phenyl ester (14.333%) and formic acid phenyl ester (6.251%), indicating that esterified aromatic compounds form part of the phytochemical composition of the stem extract. In addition, compounds such as 3-methylpyridazine (8.478%) and 5-vinyl-pyrazole contribute to the chemical diversity of the extract. The hydrocarbon compound 1,3,5,7-

cyclooctatetraene was also identified with a relative abundance of 7.653%.

**Root Extract**

Table 3 presents the phytochemical compounds identified in the methanolic root extract of *Hyptis suaveolens*. Among the detected constituents, cis-vaccenic acid was the most abundant compound, accounting for the highest peak area (37.055%), indicating it constitutes a major fraction of the root extract. Other prominent compounds included 9-octadecenoic acid (Z)-, methyl ester (13.250%), pentadecanoic acid, 14-methyl-, methyl ester (13.086%), and n-hexadecanoic acid (12.714%), all of which are fatty acid derivatives that significantly contribute to the chemical composition of the extract. Additionally, oleic acid (6.020%) and methyl stearate (5.071%) were detected in moderate quantities. Several other constituents were identified in smaller proportions, including methyl 10-trans,12-cis-octadecadienoate (4.482%), cyclododecane (2.596%), 15-octadecenoic acid, methyl ester (2.293%), 8,11-octadecadienoic acid, methyl ester (1.221%), and neophytadiene (1.195%). Trace amounts of 4,7-methano-1H-indene, octahydro-(0.458%), undec-10-ynoic acid, undec-2-en-1-yl ester (0.311%), and D-arabinose (0.249%) were also detected.

**Table 1. Compounds Identified from the Methanolic Leaves Extract of *Hyptis suaveolens***

Peak	Compounds	RT (Mins)	Area %	MW
1	Phenol, 2,5-bis(1,1-dimethylethyl)-	10.116	2.593	206
2	Heneicosane	12.359	3.237	296
3	1-Docosene	13.244	2.443	308
4	Undec-10-ynoic acid, undec-2-en-1-yl ester	14.162	2.210	334
5	Hexadecanoic acid, methyl ester	14.596	11.517	270
6	1-Dodecanol, 2-methyl-, (S)-	15.016	23.592	200
7	Cyclododecane, ethyl-	15.269	2.046	196
8	9-Octadecenal, (Z)-	16.294	3.056	266
9	7-Oxabicyclo [4.1.0] heptane, 1,5-dimethyl-	16.418	17.235	126
10	Heptadecanoic acid, 16-methyl-, methyl ester	16.530	5.244	298
11	9,17-Octadecadienal, (Z)-	16.681	14.404	264
12	Undec-10-ynoic acid, nonyl ester	16.882	4.018	308
13	Undec-10-ynoic acid, undecyl ester	17.127	3.723	338
14	2-Decen-1-ol, (E)-	17.441	4.781	156

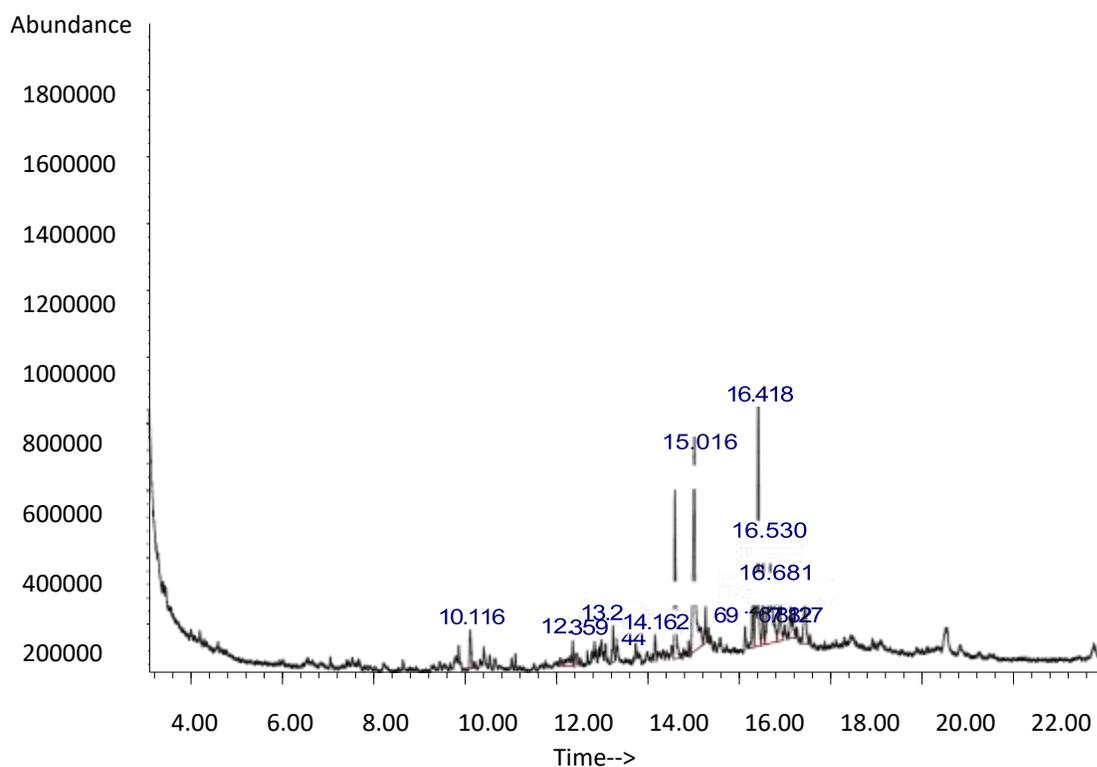


Fig. 1: Chromatogram Showing GC-MS Result of Methanolic Leaves Extract of *Hyptis suaveolens*

Table 2. Compounds Identified from the Methanolic Stem Extract of *Hyptis suaveolens*

Peak	Compounds	RT (Mins)	Area %	MW
1	5-Vinyl-pyrazole	9.861	7.491	94
2	Propanedinitrile, methylene	10.124	15.278	78
3	1,3,5,7-Cyclooctatetraene	10.412	7.653	104
4	3-Methylpyridazine	12.352	8.478	94
5	Acetic acid, phenyl ester	13.804	14.333	136
6	Formic acid phenyl ester	14.589	6.251	122
7	3-Cyclopentyl-1-propyne	14.607	19.793	107
8	5-Vinyl-pyrazole	16.405	20.723	94

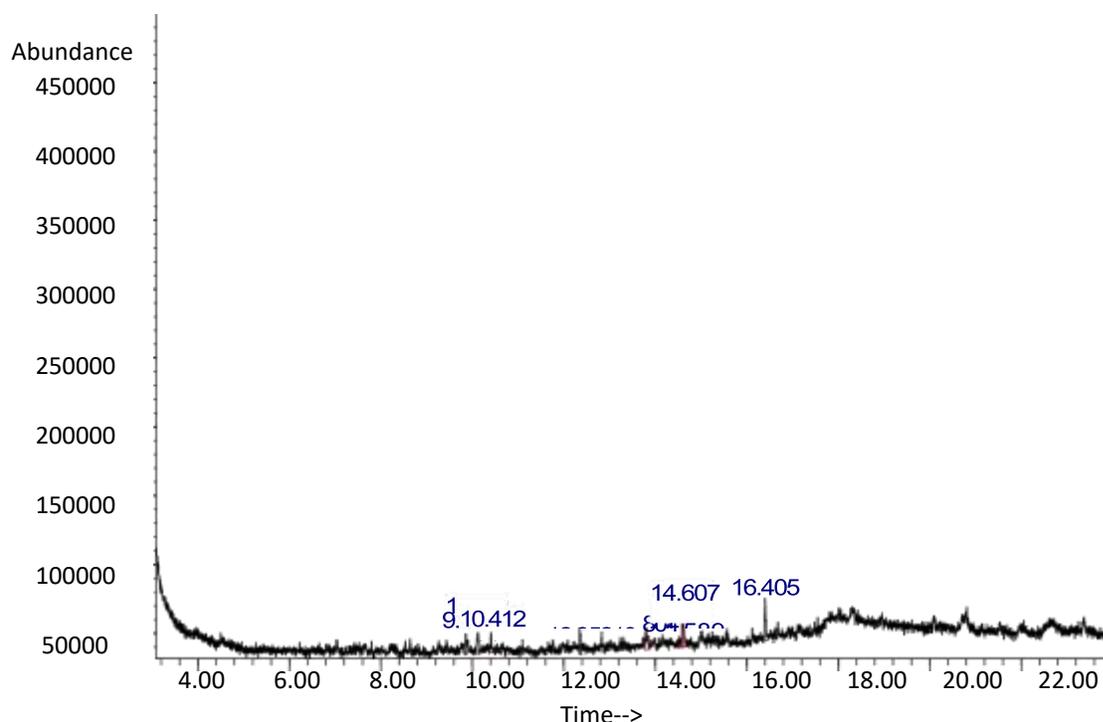
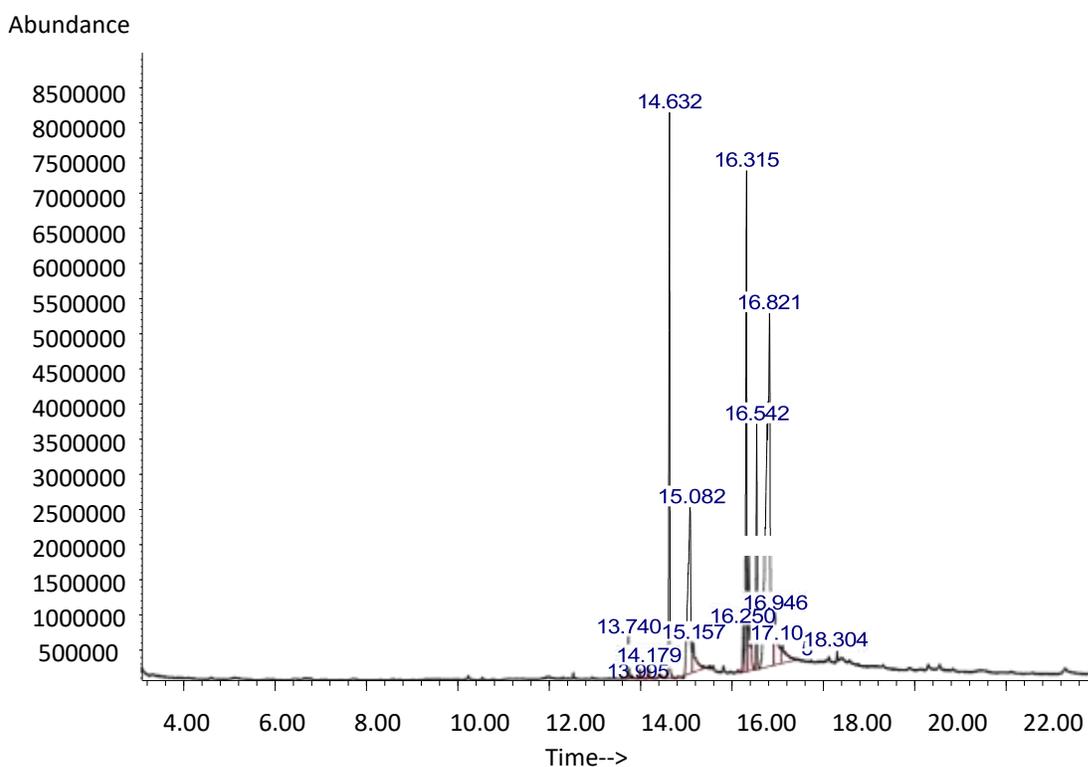


Fig. 2: Chromatogram Showing GC-MS Result of Methanolic Stem Extract of *Hyptis Suaveolens*

Table 3. Compounds Identified from the Methanolic Root Extract of *Hyptis suaveolens*

Peak	Compounds	RT (Mins)	Area %	MW
1	Neophytadiene	13.740	1.195	278
2	Undec-10-ynoic acid, undec-2-en-1-yl ester	13.995	0.311	334
3	4,7-Methano-1H-indene, octahydro-	14.179	0.458	136
4	Pentadecanoic acid, 14-methyl-, methyl ester	14.632	13.086	270
5	n-Hexadecanoic acid	15.082	12.714	256
6	Cyclododecane	15.157	2.596	168
7	8,11-Octadecadienoic acid, methyl ester	16.250	1.221	294
8	9-Octadecenoic acid (Z)-, methyl ester	16.315	13.250	296
9	Methyl stearate	16.369	5.071	298
10	Oleic Acid	16.542	6.020	280
11	cis-Vaccenic acid	16.821	37.055	282
12	Methyl 10-trans,12-cis-octadecadienoate	16.946	4.482	294
13	15-Octadecenoic acid, methyl ester	17.105	2.293	296
14	D-Arabinose	18.304	0.249	133



**Fig. 3: Chromatogram Showing GC-MS Result of Methanolic Root Extract of *Hyptis Suaveolens***

## DISCUSSION

The GC-MS profiling of the methanolic extracts of *Hyptis suaveolens* leaves, stem, and root revealed a chemically diverse spectrum of phytoconstituents belonging to several classes, including fatty alcohols, aldehydes, fatty acids, fatty acid esters, phenolic compounds, hydrocarbons, and heterocyclic derivatives. The occurrence of these compounds demonstrates the metabolic complexity of the species and supports previous reports that *H. suaveolens* contains a wide variety of biologically active secondary metabolites (Oguntibeju and Igbokwe, 2019; Mishra *et al.*, 2021).

In the methanolic leaves extract, 1-dodecanol, 2-methyl-, (S)- was the most abundant compound (23.592%). Fatty alcohol derivatives such as this compound are well known in medicinal plants (Onwuke *et al.*, 2020). The presence of 7-oxabicyclo [4.1.0] heptane, 1,5-dimethyl- (17.235%) and 9,17-octadecadienal (14.404%) further highlights the presence of oxygenated and aldehydic compounds in the leaves. The presence of aldehyde phytochemicals agree with previous report by (Silva *et al.*, 2012; Nogueira *et al.*, 2014) who reported its presence in the *Lamiaceae* family. Additionally, the detection of hexadecanoic acid methyl ester (11.517%) and other fatty acid derivatives suggests the occurrence of lipid-

related metabolites in the leaves extract. Similar fatty acid esters have previously been reported in GC-MS analyses of *H. suaveolens* and other medicinal plants (Raza *et al.*, 2015; Ajayi *et al.*, 2019). The detection of phenolic compounds such as phenol, 2,5-bis(1,1-dimethylethyl) also supports earlier studies that reported phenolic constituents in *H. suaveolens* (Oguntibeju and Igbokwe, 2019).

The stem extract exhibited a distinct chemical profile characterized predominantly by heterocyclic and aromatic compounds. The most abundant compound detected was 5-vinyl-pyrazole (20.723%), which also appeared at another retention time (7.491%), possibly indicating the presence of structural isomers or conformational variants. The presence of pyrazole derivatives agree with (Kumar *et al.*, 2018) who reported its presence in the *H. suaveolens*. The presence of 3-cyclopentyl-1-propyne (19.793%) and propanedinitrile, methylene (15.278%) further indicates the presence of alkyne and nitrile derivatives within the stem extract. Compounds belonging to these chemical groups have been reported in medicinal plants (Ntie-Kang *et al.*, 2017). The detection of aromatic esters such as acetic acid, phenyl ester and formic acid phenyl ester also suggests the presence of aromatic metabolites (Akinmoladun *et al.*, 2014). Generally, the

predominance of heterocyclic and aromatic compounds in the stem extract suggests that the stem may serve as an important reservoir of structurally diverse bioactive metabolites.

The root extract displayed a phytochemical profile largely dominated by fatty acids and their derivatives. The most abundant compound detected was *cis*-vaccenic acid (37.055%), followed by 9-octadecenoic acid (*Z*-), methyl ester (13.250%), pentadecanoic acid, 14-methyl-, methyl ester (13.086%), and *n*-hexadecanoic acid (12.714%). Fatty acids and their esters are well known bioactive compounds in *Lamiaceae* family as reported by (Ramírez *et al.*, 2012; Yadav and Tembe, 2017). In addition, unsaturated fatty acids such as oleic acid and vaccenic acid have been reported in the *Lamiaceae* (Ramírez *et al.*, 2012). The detection of these compounds in the root extract also supports previous report on *H. suaveolens* (Okokon *et al.*, 2017). Minor constituents such as neophytadiene were also detected in the root extract. Neophytadiene is a diterpenoid compound previously reported by (Duraipandiyani *et al.*, 2011) in the *Hyptis suaveolens* as antimalarial compound. The presence of such compounds may support the pharmacological relevance of the root extract. The results obtained align with prior phytochemical screenings of *Hyptis suaveolens*. For instance, Edeoga *et al.* (2006) and Akinmoladun *et al.* (2007) reported the presence of fatty acids, esters, and terpenes in *Hyptis suaveolens* extracts.

Comparative evaluation of the phytochemical composition across plant parts revealed organ-specific variations in chemical constituents. The leaves were dominated by fatty alcohols, aldehydes, and esters, the stem contained a higher proportion of heterocyclic and aromatic compounds, while the root extract was largely composed of fatty acids and their methyl esters. Such variations in metabolite distribution among different plant organs are commonly observed in medicinal plants and are often associated with differences in physiological function, ecological adaptation, and metabolic specialization (Starlin *et al.*, 2019). These findings therefore highlight the importance of investigating multiple plant parts when conducting phytochemical profiling studies.

Generally, the GC–MS analysis presented in this study provides valuable evidence into the chemical composition of methanolic extracts of *Hyptis suaveolens*. The detection of several compounds previously associated with antimicrobial, antioxidant, and antimalarial activities supports the ethnomedicinal use of the plant. However, it should

be noted that GC–MS analysis primarily provides chemical characterization, and the biological activities of the identified compounds require further validation through bioassay-guided isolation, pharmacological evaluation, and mechanistic studies.

## CONCLUSION

The GC–MS analysis of methanolic extracts of leaves, stem, and root of *Hyptis suaveolens* revealed a diverse array of phytochemicals, including fatty alcohols, aldehydes, fatty acid esters, phenolic compounds, hydrocarbons, heterocyclic derivatives, and terpenoid-related compounds, with distinct organ specific distributions: leaves were rich in fatty alcohols, aldehydes, and phenolics; the stem contained notable heterocyclic, alkyne, and nitrile compounds; and the root was predominantly composed of fatty acid derivatives and minor terpenoids. This study provides a comprehensive chemical list of *H. suaveolens*, highlighting its secondary metabolite diversity and establishing a foundation for further phytochemical investigations. However, the work is limited to chemical profiling using GC–MS and does not include *in vitro* or *in vivo* biological assays. Therefore, compounds identified in *H. suaveolens* extracts particularly those with highest peak area should be isolated, purified, and characterized to clarify their mechanisms of action and potential therapeutic applications.

## REFERENCES

- Abdullahi, M. S., Lawal, B., and Yahaya, M. (2020). Ethnobotanical survey of medicinal plants used in the management of malaria in Northern Nigeria. *Journal of Ethnopharmacology*, 252, 112530. <https://doi.org/10.1016/j.jep.2020.112530>
- Akinmoladun, F. O., Akinrinlola, B. L., and Farombi, E. O. (2007). Phytochemical constituents and antioxidant activity of extract from the leaves of *Hyptis suaveolens*. *African Journal of Biotechnology*, 6(10), 1196–1200.
- Akinmoladun, F. O., Akinrinlola, B. L., and Komolafe, T. O. (2014). Antiplasmodial activity and GC-MS analysis of the methanol extract of *Hyptis suaveolens* leaves. *African Journal of Traditional, Complementary and Alternative Medicines*, 11(5), 124–129. <https://doi.org/10.4314/ajtcam.v11i5.17>
- Amaka, J., Attah, D., Obisike, V., and Benedict, A. G. (2018). Evaluation of the larvicidal potential of the leaf extracts of *Hyptis suaveolens* poit against anopheles' mosquitoes. *Asian Journal of Research in Zoology*, 1-9. <https://doi.org/10.9734/ajriz/2018/v1i229676>

- Ajayi, I. A., Ajibade, O., and Oderinde, R. A. (2019). Fatty acid composition and antibacterial activity of *Hyptis suaveolens* leaves. *African Journal of Pure and Applied Chemistry*, 13(3), 26–32.
- Bhat, M. A., Al-Omar, M. A., and Mohammed, A. A. (2019). Recent advances in pyrazole-containing compounds as potential antimalarial agents. *Bioorganic and Medicinal Chemistry*, 27(14), 3081–3100. <https://doi.org/10.1016/j.bmc.2019.06.017>
- Chukwu, M. N., Eze, A. A., and Okoye, F. B. C. (2022). Gas chromatographic-mass spectrometric analysis of antimalarial compounds in *Hyptis suaveolens* and their inhibitory effects on *Plasmodium falciparum*. *Natural Product Research*, 36(2), 219–225. <https://doi.org/10.1080/14786419.2020.1726992>
- Duraipandiyar, V., Ayyanar, M., and Ignacimuthu, S. (2011). Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. *BMC Complementary and Alternative Medicine*, 6, 35.
- Edeoga, H. O., Okwu, D. E., and Mbaebie, B. O. (2006). Phytochemical constituents of some Nigerian medicinal plants. *African Journal of Biotechnology*, 4(7), 685–688.
- El-Sayed, A. S. A., Yassin, M. A., and Omar, N. F. (2015). Antiplasmodial activity of heterocyclic compounds: A mini-review. *Medicinal Chemistry Research*, 24, 3039–3056. <https://doi.org/10.1007/s00044-015-1382-6>
- Ezekwesili-Ofili, J. O., Okaka, A. N. C., and Ofor, O. E. (2016). Antioxidant and antimalarial potential of phenolic-rich extracts of Nigerian plants. *Journal of Ethnopharmacology*, 191, 188–194.
- Ghaffari, H., Ghassam, B., Nayaka, S., Kini, K., and Shetty, S. (2014). Antioxidant and neuroprotective activities of *Hyptis suaveolens* (L.) poit. against oxidative stress-induced neurotoxicity. *Cellular and Molecular Neurobiology*, 34(3), 323–331. <https://doi.org/10.1007/s10571-013-0016-7>
- Jiang, Y., Wang, J., and Shen, Q. (2011). Fatty acid derivatives from plants: Potential antimalarial agents. *Fitoterapia*, 82(7), 976–981
- Kaur, K., Jain, M., Kaur, T., and Jain, R. (2015). Antimalarials from nature. *Bioorganic and Medicinal Chemistry*, 17(9), 3229–3256.
- Kondamudi, R., Strull, G., and Yan, S. (2014). Hydrocarbon fuel production from lipids by catalytic deoxygenation. *Fuel*, 115, 324–329.
- Kumar, S., Bawa, S., and Drabu, S. (2018). Pyrazole derivatives as potential antimalarial agents: Synthesis and biological evaluation. *European Journal of Medicinal Chemistry*, 151, 245–260. <https://doi.org/10.1016/j.ejmech.2018.03.043>
- Kumar, S., Guha, M., Choubey, V., Maity, P., and Bandyopadhyay, U. (2014). Antimalarial drugs inhibiting hemozoin ( $\beta$ -hematin) formation: A mechanistic update. *Life Sciences*, 89(17–18), 525–530.
- Mishra, P., Sohrab, S., and Mishra, S. (2021). A review on the phytochemical and pharmacological properties of *Hyptis suaveolens* (L.) poit. *Future Journal of Pharmaceutical Sciences*, 7(1). <https://doi.org/10.1186/s43094-021-00219-1>
- Nogueira, K. L., Oliveira, B. G., and Leite, A. C. (2014). Evaluation of aliphatic aldehydes as antiplasmodial agents: Synthesis and biological studies. *Medicinal Chemistry Research*, 23(6), 2781–2788.
- Ntie-Kang, F., Onguéné, P. A., and Lifongo, L. L. (2017). The potential of naturally occurring cycloalkyl and alkyne derivatives in the treatment of parasitic infections: A cheminformatic analysis. *BMC Complementary and Alternative Medicine*, 17, 162. <https://doi.org/10.1186/s12906-017-1652-8>
- Oguntibeju, O. O., and Igbokwe, C. O. (2019). Phytochemical screening and GC-MS analysis of the leaves of *Hyptis suaveolens* and its antimicrobial activity. *African Journal of Pharmacy and Pharmacology*, 13(12), 170–176.
- Ogunwande, I. A., Walker, T. M., Ayinde, O. O., and Orafidiya, L. O. (2021). Chemical composition and antimalarial activity of some Nigerian medicinal plants. *Natural Product Research*, 35(14), 2311–2316.
- Okokon, J. E., Udoh, A. E., and Frank, S. G. (2017). Antimalarial and toxicological studies of root extract of *Hyptis suaveolens*. *Asian Pacific Journal of Tropical Medicine*, 10(6), 566–570.
- Olorunfemi, O. J., Adepoju, G. K., and Akinboro, A. (2021). Evaluation of antiplasmodial activities of *Hyptis suaveolens* extracts in malaria-infected mice. *Journal of Applied Pharmaceutical Science*, 11(7), 110–116. <https://doi.org/10.7324/JAPS.2021.110712>
- Omoriegie, E. H., Pal, A., and Kumar, S. (2013). Antiplasmodial and phytochemical screening of extracts from *Euphorbia hirta* and *Euphorbia heterophylla*. *Asian Pacific Journal of Tropical Disease*, 3(3), 238–241.
- Onwuke, C. M., Igwilo, I. O., and Okoli, C. O. (2020). Mechanistic insights into the antimalarial activity of fatty alcohols. *Journal of Applied Pharmaceutical Science*, 10(1), 102–109.
- Raza, M., Rafiq, M., and Iqbal, L. (2015). GC-MS analysis and screening of antimalarial activities of medicinal plants from Pakistan. *Pakistan Journal of Pharmaceutical Sciences*, 28(6), 2103–2108.
- Ramírez, D., Caballero, J., & Peña, C. (2012). Fatty acids as antimalarial agents: Inhibition of *Plasmodium*

*falciparum* development by fatty acid-rich extracts. *Molecules*, 17(6), 6821–6834.

Silva, T. M. S., Camara, C. A., and Silva, E. M. S. (2012). Fatty aldehydes and their derivatives: Biologically active compounds. *Natural Product Research*, 26(20), 1910–1915.

Starlin, T., Ps, P., Bka, T., and Gopalakrishnan, V. (2019). Screening and GC-MS profiling of ethanolic extract of *tylophora pauciflora*. *Bioinformation*, 15(6), 425-429. <https://doi.org/10.6026/97320630015425>

Tiwari, M., Singh, R. K., and Tiwari, D. (2018). Plant sugars and their roles in human health and diseases. *International Journal of Health Sciences*, 12(4), 54–60.

Xu, M., Gao, Y., Wang, X., Han, X., and Zhao, B. (2021). Comprehensive strategy for sample preparation for the analysis of food contaminants and residues by gc–ms/ms: a review of recent research trends. *Foods*, 10(10), 2473.

<https://doi.org/10.3390/foods10102473>

Yadav, M., and Tembe, B. L. (2017). Antimalarial strategies targeting the fatty acid biosynthesis pathway of *Plasmodium falciparum*. *Journal of Tropical Medicine*, 2017, 1–8.

Zhou, L., Wu, J., and Wang, T. (2018). Discovery of ether-containing antimalarial agents: Recent advances. *European Journal of Medicinal Chemistry*, 143, 899–910.