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Gas Chromatography-Mass Spectrometry (GC-MS) Analysis of Some Plants Extract

Salihu Takuma*, Siaka Abdulfatai Adabara and Kamal Suleiman Kabo
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Abstract: *The Gas Chromatography-Mass Spectrometry (GC-MS) analysis of four plant extracts—Tamarindus indica Seed Extract (TISE), Tamarindus indica Pulp Extract (TIPE), Acacia nilotica Seed Extract (ANSE), and Acacia nilotica Pulp Extract (ANPE)—revealed the presence of diverse bioactive compounds with varying concentrations. TISE was found to contain seventeen bioactive molecules, with Dimethyl sulphide (42.68%), S-ethylmethanethiosulphonate (26.31%), and 9-octadecenamide (11.01%) as the predominant compounds. TIPE, with thirteen bioactive compounds, exhibited ethanethiol (74.29%) and 9-octadecenamide (11.55%) as the major constituents. ANSE comprised seventeen compounds, with Dimethylsulphide (13.85%), 2-Propanol (6.07%), 1,2,3-benzenetriol (5.22%), and 9,12-octadecadienoic acid (14.24%) being some of the most prominent. In ANPE, sixteen bioactive compounds were detected, with Benzoic acid, 3,4,5-trihydroxy, methyl ester (50.47%) and 9-octadecenamide (23.57%) dominating the extract.Dimethylsulphide showed the highest peak values in both TISE and TIPE, with retention times of 1.442 and 1.440 minutes and percent peak areas of 42.68% and 74.29%, respectively. In ANSE, 9,12-octadecadienoic acid exhibited the highest peak at a retention time of 52.916 minutes with a peak area of 14.24%. In ANPE, Benzoic acid, 3,4,5-trihydroxy, methyl ester had the highest peak, with a retention time of 41.107 minutes and a peak area of 50.47%. This study highlights the presence of several bioactive compounds, particularly fatty acids, amides, and aromatic molecules, which suggest potential applications in fields such as pharmaceuticals, nutrition, and material science. Further investigation is recommended to isolate, identify, and characterize these bioactive compounds for their potential industrial applications, including in the development of eco-friendly corrosion inhibitors and other biotechnological uses.*

Keywords: *TISE, TIPE, ANSE, ANPE, Phytochemical constituents, and GC-MS*

Salihu Takuma*,
Federal University Dutsin-Ma, Katsina NigeriaFederal College of Education (Tech), x Zamfara State, Nigeria
E-mail: salihutakuma2@gmail.com
Orcid id: 0009-0002-0585-7436

Siaka Abdulfatai Adabara
Department of Applied Chemistry Federal University Dutsin-Ma, Katsina Nigeria
Email: fatsaadaby@gmail.com
Orcid id: 0000-0001-8527-5780

Kamal Suleiman Kabo
Department of Applied Chemistry Federal University Dutsin-Ma, Katsina Nigeria
Email: kamalskabo@yahoo.com

1.0 Introduction

The role of a corrosion inhibitor is often regarded as the most practical and least time-consuming method of combating corrosion (Umoren and Solomon (2014). Synthetic inhibitors are highly toxic and expensive; hence the search for natural non-toxic substances is of utmost importance (8). Most plants and plant extracts are low-cost, non-toxic, renewable and biodegradable; therefore, they can be used as a substitute for harmful organic inhibitors. Additionally, the extraction procedure is easy and inexpensive.

Corrosion inhibitors that are mild on the planet`s ecosystem may be derived from many different plant components, including pulp, leaves, bark, roots, seeds and peels. A plant's non-nutritional components that contribute to its fragrance, taste and colour are referred to as phytochemicals and these components are all part of the plant`s chemical makeup. There is a resemblance between the electronic structures of phytochemicals and those of common synthetic organic corrosion inhibitors. (Singh *et* al., 2016; Verma *et* al., 2018; Ong *et al*., 2021) These organic compounds provide a barrier against corrosion on metals and alloys as a result of the adsorption of their heteroatoms and pi (λ) - electrons on the surface of the metal or alloy (Mustapha, 2021; Nayem *et al*., 2023).

Despite the great availability and variety of plant materials, only relatively few have been thoroughly investigated (Mustapha, 2021). This study focuses on the identification of core and minor active phytochemical constituents present in these plant extracts using GC-MS analytical method.

2. 0 Materials and Methods

2.1 Collection of Plant Materials

The fruits of *acacia nilotica* were manually collected from Federal College Education (Tech), Gusau, and its environments. The fruits collected were dehulled, washed and dried at room temperature for a week. The seeds were removed from the pulp manually washed and dried. The dried pulp and seed powder were obtained by grinding each separately and stored in separate airtight polythene bags.

2.2 Extraction of the Plants Materials

The extraction was done by weighing 150 g of each powdered sample using a digital analytical balance with sensitivity ± 0.0001 which was soaked in 350 ml of 99.8% aqueous methanol analar grade in 1000 ml of separating funnel, agitated and left for one week (168 hrs) at room temperature. The residues were removed by double filtration, first with clean white muslin cloth and then with Whatman filter papers. The filtrate was further evaporated to have methanol free samples using rotary evaporator (Petro and Anada, 2017). The semi-solid extracts obtained for *acacia niotica* pulps extract (ANPE), *acacia niotica* seeds extract (ANSE), *tamarindus indica* pulps extract (TIPE) and *tamarindus indica* seeds extract (TISE) were stored in a separate 125 ml glass bottles for corrosion studies.

2.3 Gas Chromatography-Mass Spectroscopy (GC-MS) Analysis

The phytochemical components of selected plant extracts were identified using GC-MS detection system. The GC-MS was accomplished using an Agilent 19091s GC system. The capillary column used was 933HP-1MS (30 × 250 µm; film thickness of 0.25 µm; J & W Scientific USA). Identification and interpretation of compounds on Mass-Spectrum GCMS were conducted using the database of the National Institute of Standard and Technology (NIST) having more than 62,000 patterns. The spectrum of individual unknown compounds was compared with the spectrum of known components stored in the NIST library. The name, molecular formula, weight and chemical structures of the components of the test materials were ascertained. This analysis was carried out at the instrumentation laboratory ground floor, H-block School of Chemistry and Physics, College of Agriculture, Engineering and Science, University of KwaZulu Natal, Republic of South Africa.

3. 0 Results and Discussion

The results and discussion of GC-MS analysis of selected plants are presented in the following headings:

3.1 Tamarindus indica Seed Extract (TISE)

The GC-MS analysis of *Tamarindus indica* Seed Extract (TISE) revealed the presence of a diverse range of bioactive compounds,

indicating the extract's potential in various biological and industrial applications. A total of seventeen compounds were identified, each characterized by specific retention time (RT), molecular formula (MF), molecular weight (MW), and concentration as expressed by the % peak area. These compounds, presented in Table 1, span multiple chemical classes, including sulfur compounds, fatty acids, esters, alcohols, and amides. The chromatogram obtained (Fig. 1) displays distinct peaks corresponding to these compounds, with major contributors dominating the spectrum.

Table 1: Phytochemical Constituents Identified in TISE by GC-MS study

Peak line	RT (min)	MF	MW (g/mol)	Compound Name	% Peak area
1	1.173	C5H4O	70	2, 5 – Furandione	1.62
2	1.442	C2H6S	62	Dimethylsulphide	42.68
3	1.570	C2H6OS2	110	S-Methylmethanethiosulphonate	26.31
4	1.801	C4H6O	70	3 – Butyn – 1 – ol	1.97
5	1.864	C3H8O	60	2 – Propanol (Isopropylalcohol)	1.68
6	31.329	C7H14O6	194	Alpha-D-Glucopyranoside, methyl	4.07
7	41.167	C17H34O2	270	Hexadecanoic acid, methylester	0.70
8	43.741	C16H32O2	256	N – Hexadecanoic acid	1.31
9	52.912	C19H34O2	294	9, 12-Octadecadienoic acid (ZZ)-, methylester	1.94
10	53.324	C19H36O2	296	9-Octadecanoic acid, methylester	1.52
11	54.854	C18H32O2	280	9, 12-Octadecadienoic acid (ZZ)	1.10
12	55.153	C18H34O2	282	Oleic acid	1.44
13	56.391	C16H33NO	255	Hexadecenamide	1.47
14	61.071	C20H36O2	308	Linoleic acid, ethylester	0.61
15	61.271	C18H35NO	281	9 – Octadecenamide, (Z)-	11.01
16	61.888	C14H29NO	227	Tetradecanamide	0.39
17	68.096	C25H50O2	382	Tetracosanoic acid, methylester	0.18

The high concentration of Dimethylsulphide (42.68%) in the extract makes it the most abundant compound. Dimethylsulphide is a sulfur-containing compound often associated with antimicrobial and antifungal properties. Similar studies have reported the dominance of sulfur derivatives in plant extracts, attributing their biological efficacy to their ability to interfere with microbial metabolism and oxidative stress pathways. This compound, along with S-Methylmethanethiosulphonate (26.31%), contributes to the strong antimicrobial potential of *Tamarindus indica*. The latter is an organosulfur compound widely recognized for its antioxidant properties and capability to mitigate oxidative stress, as corroborated by similar findings in garlic and onion extracts. Another significant compound, 9-Octadecenamide, (Z)- (11.01%), is an amide compound often linked to anti-inflammatory and anticancer activities. Its relatively high concentration suggests its role as a bioactive agent in therapeutic applications. Such compounds have been highlighted in literature for their involvement in cell signalling pathways and their ability to inhibit inflammatory mediators. Fatty acids and their derivatives, including N-Hexadecanoic acid (1.31%), Hexadecanoic acid methylester (0.70%), and Oleic acid (1.44%), are present in moderate concentrations in the extract. These compounds are known for their emollient, anti-

inflammatory, and lipid-regulating properties, making them valuable in both pharmaceutical and cosmetic formulations. The unsaturated fatty acids, such as Linoleic acid ethyl ester (0.61%) and 9,12-Octadecadienoic acid, methyl ester (1.94%), are particularly noteworthy for their roles in maintaining cardiovascular health and reducing oxidative damage. Carbohydrate derivatives, such as Alpha-D-Glucopyranoside, and methyl (4.07%), indicate the presence of natural sugars in the extract, which may stabilize bioactive compounds or serve as a source of metabolic energy. Additionally, compounds such as 2,5-Furandione (1.62%) and 3-Butyn-1-ol (1.97%) suggest the presence of bioactive molecules with antibacterial or industrial utility, as such compounds are frequently employed as intermediates in organic synthesis.

Low-concentration compounds like Tetradecanamide (0.39%) and Tetracosanoic acid methyl ester (0.18%) may play a role in enhancing the stability or hydrophobicity of the extract. Despite their small quantities, these long-chain fatty acids and amides are critical for the overall bioactivity of the extract. The findings from this analysis align with previous studies on *Tamarindus indica*, which report its rich phytochemical composition and multifunctional applications. This diversity underscores the extract's potential for pharmaceutical, cosmetic, and industrial applications. Further investigations, including bioassays and in vivo studies, are recommended to validate these findings and explore the therapeutic and industrial potential of TISE.

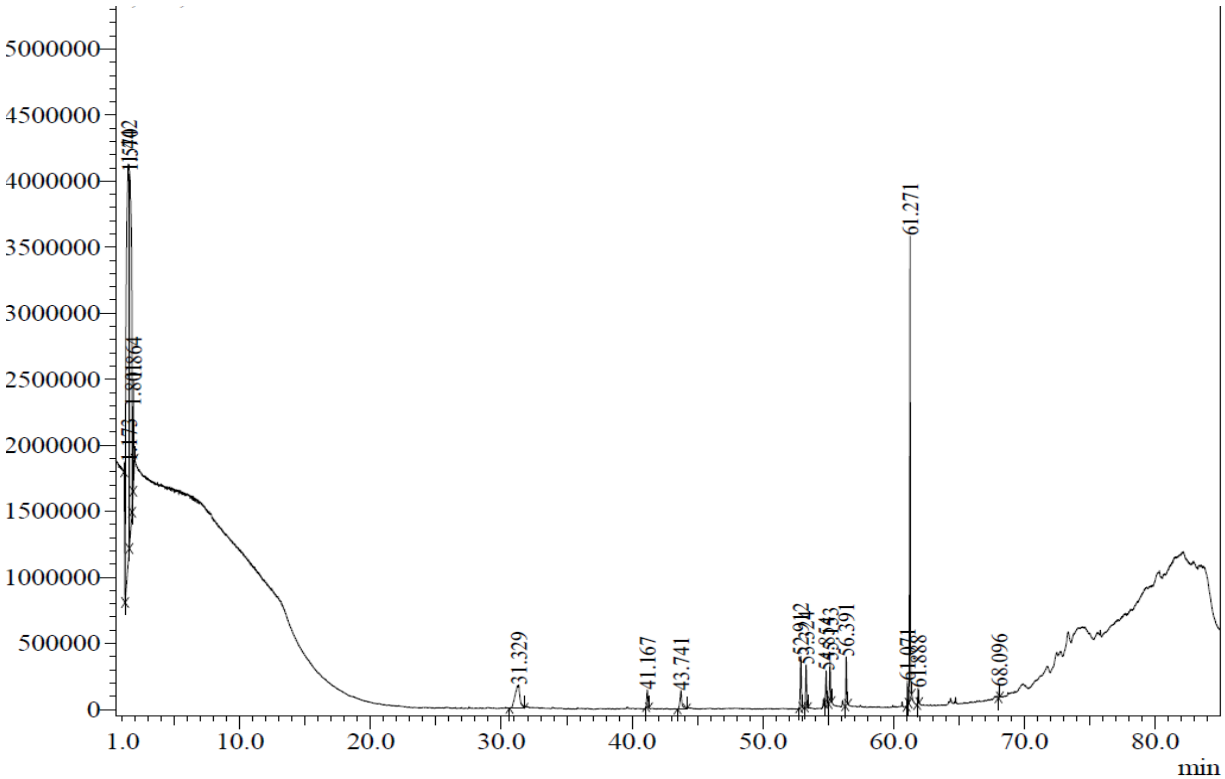
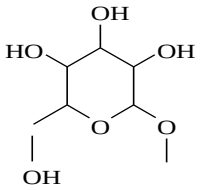
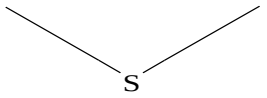


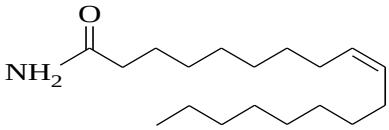
Fig. 1: GC-MS Chromatogram of TISE showing Different Peaks



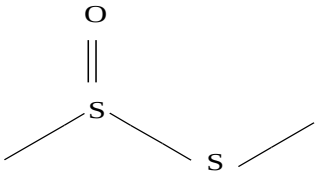
2. Alpha-D-Glucopyranteoside, methyl ester



1. Dimethylsulphide



3. 9-Octadecenamide, (Z)-



4. S-Methyl methanethiosulphonate

Fig.2: Chemical Structures and Names of Phytochemical Molecules in TISE

From the results presented in the Table above, it is evident that the phytochemical constituents of TISE can be classified into different hydrocarbons (including molecules with heteroatoms). The structures of major phytochemical constituents present in the extract are depicted in Fig. 2. In terms of percent peak area, dimethyl sulphide (42.68), S – methyl methane thiosulphonate (26.31), alpha – D – glucopyranoside, methyl (4.07), and 9 – octadecenamide (Z)- (11.01) were found to be the major compounds forming the dominant components in TISE while 2, 5 – furandione (1.62), 3 – butyn-1-ol (1.97), 2-propanol (1.68), hexadecanoic acid, methyl ester (0.70), n-hexadecanoic acid (1.31), 9, 12 – octadecadienoic acid (ZZ),- methyl ester (1.94), 9-octadecenoic acid, methyl ester (1.52), 9,12-octadecadienoic acid (ZZ) (1.10), oleic acid (1.44), hexadecanamide (1.47), linoleic acid, ethyl ester (0.61) and tetradecanamide (0.39) are among the minor compounds in the extract (Nnabuk *et* al., 2011; Joseph *et al*., 2015; Siaka *et al*., 2019; Idu *et al.,* 2021 and Asril *et al*., 2024). From this study, dimethyl sulphide indicated the highest peak value in the extract with a retention time of 1.442 minutes and percent peak area of 42.68 (Idu *et al.,* 2021). However, the compounds pertaining to the peak were identified by comparing the NIST library data of the peak and mass spectra of the peak with those reported in the literature.

3.2 Tamarindus indica Pulp Extract (TIPE)

The GC-MS analysis of *Tamarindus indica* Pulp Extract (TIPE) unveiled the presence of thirteen distinct phytochemical compounds with varying chemical structures and properties. These compounds, identified based on their retention time (RT), molecular formula (MF), molecular weight (MW), and concentration (% peak area), are summarized in Table 2. The chromatogram of the TIPE sample displays well-defined peaks, corresponding to these identified constituents, which highlight the extract's rich and diverse chemical composition. This abundance suggests its primary role in the biological activities of *Tamarindus indica* pulp.9-Octadecenamide, also known as oleamide, is another significant compound, accounting for 11.55% of the extract. Oleamide is an amide compound with known anti-inflammatory, sedative, and antimicrobial activities.

Table 2: Phytochemical Constituents Identified in TIPE by GC-MS study

Peak line	RT (min)	MF	MW (g/mol)	Compound Name	% Peak area
1	1.205	C4H6O	70	3-Butyn-1-ol	0.86
2	1.440	C2H6S	62	Ethanethiol	74.29
3	1.786	C3H3NO2	85	Acetic acid, cyano-	2.11
4	1.850	C3H8O	60	2-Propanol (Isopropylalcohol)	2.04
5	20.105	C6H6O3	126	5-Hydroxymethylfurfural	1.39
6	41.159	C17H34O2	270	Hexadecanoic acid	1.62
7	43.671	C16H32O2	256	n-Hexadecanoic acid	0.82
8	52.895	C19H34O2	294	9,12-Octadecadienoic acid	0.72
9	53.145	C19H32O2	292	9,12,15-Octadecatrienoic acid	1.07
10	53.310	C19H36O2	296	9-Octadecenoic acid	1.55
11	56.363	C16H33NO	255	Hexadecanamide	1.20
12	61.256	C18H35NO	281	9-Octadecenamide	11.55
13	75.822	C27H46O	386	Cholesterol	2.24

Literature has documented its influence on central nervous system signaling and its utility in promoting relaxation and reducing inflammation. This compound adds therapeutic value to the pulp extract.Other bioactive compounds identified include fatty acids such as Hexadecanoic acid (1.62%), n-hexadecanoic acid (0.82%), and 9-octadecenoic acid (1.55%). These compounds are commonly associated with lipid metabolism, anti-inflammatory properties, and skin health. Fatty acids like 9,12-Octadecadienoic acid (0.72%) and 9,12,15-Octadecatrienoic acid (1.07%) are unsaturated fatty acids that serve as precursors for bioactive lipid mediators, contributing to cardiovascular health and antioxidant activity. Cholesterol, present at 2.24%, is a sterol that is vital for cellular membrane integrity and serves as a precursor for steroid hormone biosynthesis. Its presence in the extract may also contribute to its structural and biological properties. Minor constituents such as 3-Butyn-1-ol (0.86%) and 5-Hydroxymethylfurfural (1.39%) are known for their industrial and medicinal applications. 3-Butyn-1-ol is often utilized as a chemical intermediate, while 5-Hydroxymethylfurfural is a compound of interest in pharmaceuticals due to its antioxidant properties.

The results align with previous reports on the phytochemical richness of *Tamarindus indica* pulp, which has been recognized for its applications in traditional medicine, functional foods, and nutraceuticals. The chemical diversity of TIPE suggests its potential utility in the pharmaceutical, food, and cosmetic industries. Further bioassays and experimental validations are required to explore the biological activities and applications of these identified compounds.

The results provided in Table 2 and GC-MS chromatogram of TIPE show distinct peaks of identified compounds as shown in Fig. 3. The structures of major phytochemical constituents present in the extract are depicted in Fig. 4.

In terms of percent peak area, ethanethiol (74.29) and 9-octadecenamide (11.55) were found to be the major compounds forming the dominant components in TIPE. 3 – butyn-1-ol (0.86), acetic acid cyano- (2.11), 2-propanol (2.04), 5 – hydroxylmethyl furfural (1.39), hexadecanoic acid (1.62), n-hexadecanoic acid (0.82), 9, 12, 15 – octadecatrienoicacid (1.07), 9 – octadecenoic acid (1.55), hexadecanamide

(1.20), Chloresterol (2.24) and tetracosanoic acid (0.18) are minor compounds present in TIPE (Eddy *et* al., 2011; Joseph *et al*., 2015; Siaka *et al*., 2019; Idu *et al*., 2021 and Asril *et al*., 2024). In this study, dimethylsulphide indicated the highest peak value with a retention time of 1.440 minutes and % peak area of 74.29 (Idu *et al.*, 2021).

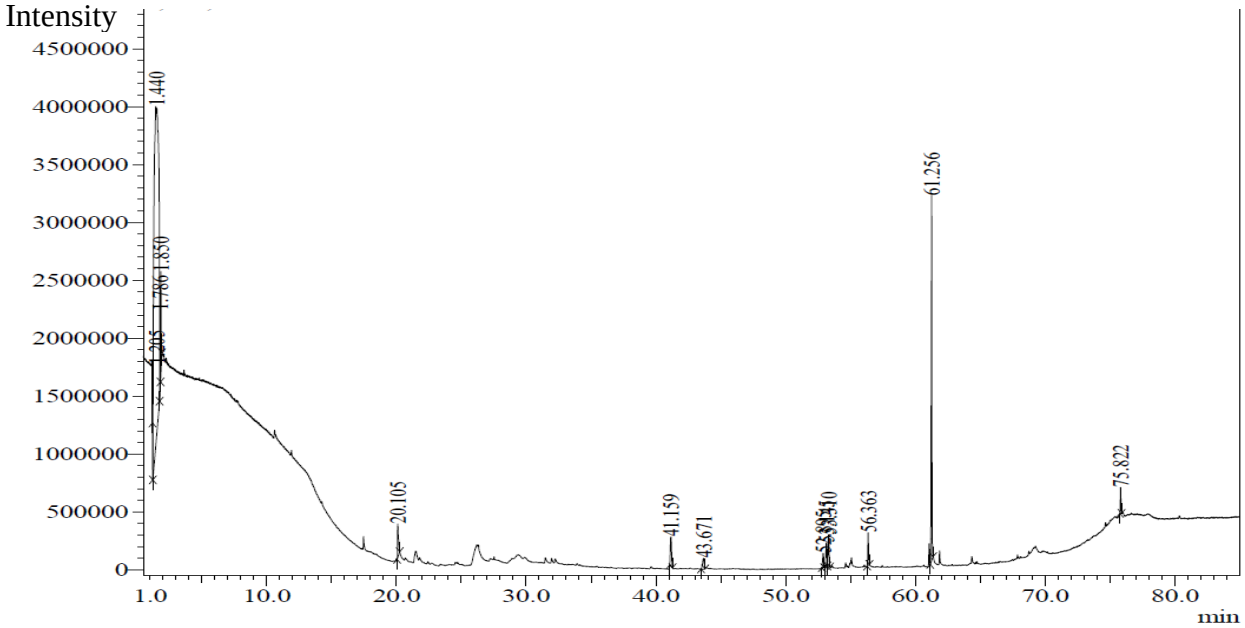


Fig. 3: GC-MS Chromatogram of TIPE showing Different Peaks

1. Ethanethiol 2. 9-Octadecenamide, (Z)-

Fig.4: Chemical Structures and Names of Phytochemical Molecules in TIPE

3.3 *Acacia nilotica* seed extract

The GC-MS analysis of *Acacia nilotica* Seed Extract (ANSE) revealed the presence of seventeen distinct phytochemical compounds, each characterized by its retention time (RT), molecular formula (MF), molecular weight (MW), and concentration (% peak area). These compounds, identified using the NIST spectral library, are summarized in Table 3. The chromatogram of the ANSE illustrates well-defined peaks corresponding to these identified constituents, highlighting the extract's chemical diversity

Among the identified compounds, 9,12-Octadecadienoic acid (14.24%) was the most abundant, followed by Dimethylsulphide (13.85%) and 9-Octadecenamide (11.74%). These compounds contribute significantly to the extract's bioactivity. Dimethylsulphide, a sulfur-containing compound, is known for its antimicrobial and antioxidant properties, which can inhibit the growth of harmful microbes and neutralize reactive oxygen species. The abundance of Dimethylsulphide in ANSE highlights its potential role in medicinal and preservative applications. 9,12-Octadecadienoic acid, an unsaturated fatty acid, is well-documented for its anti-inflammatory, lipid-lowering, and antioxidant activities.

Table 3: Phytochemical Constituents Identified in ANSE by GC-MS study

Peak line	RT (min)	MF	MW (g/mol)	Compound Name	% Peak area
1	1.441	C2H6S	62	Dimethylsulphide	13.85
2	1.772	C3H3NO2	85	Cyanoacetic acid	2.58
3	1.833	C3H8O	60	2-Propanol (Isopropylalcohol)	6.07
4	24.580	C6H6O3	126	1,2,3-Benzenetriol	9.22
5	31.565	C7H14O6	194	Alpha-D-Glucopyranoside	7.37
6	41.158	C17H34O2	270	Hexadecanoic acid	5.61
7	43.856	C16H32O2	256	n-Hexadecanoic acid	2.58
8	52.916	C19H34O2	294	9,12-Octadecadienoic acid	14.24
9	53.315	C19H38O2	296	9-Octadecenoic acid	9.68
10	54.632	C19H38O2	298	Methylstearate	1.18
11	54.889	C18H32O2	280	9,12-Octadecadienoic acid (ZZ)-	8.05
12	55.184	C18H34O2	282	Oleic acid	7.72
13	56.106	C18H36O2	284	Octadecanoic acid	1.12
14	56.393	C16H33NO	255	Hexadecanamide	1.81
15	61.070	C20H36O2	308	Linoleic acid, ethylester	0.66
16	61.248	C18H35NO	281	9-Octadecenamide	11.74
17	61.878	C14H29NO	227	Tetradecanamide	0.50

Similarly, 9-octadecenamide (oleamide), an amide derivative, is recognized for its sedative, anti-inflammatory, and neuroactive properties. The presence of these compounds in ANSE suggests its utility in managing oxidative stress, inflammation, and neurological disorder rs.1,2,3-Benzenetriol (9.22%), a phenolic compound, exhibits potent antioxidant and antimicrobial effects. Literature supports its role in protecting against free radical damage and its use in pharmaceuticals as a natural preservative. Other notable compounds include Hexadecanoic acid (5.61%) and n-hexadecanoic acid (2.58%), which are saturated fatty acids with reported antioxidant, antimicrobial, and skin-protective effects. Oleic acid (7.72%), an unsaturated fatty acid, is also known for its anti-inflammatory and cardiovascular benefits. The presence of minor constituents like Methyl stearate (1.18%) and Linoleic acid, ethyl ester (0.66%) further enriches the extract's chemical profile, enhancing its potential applications in nutraceuticals and cosmetics.The chemical diversity of ANSE suggests a wide range of potential uses in the pharmaceutical, cosmetic, and food industries. Its rich content of bioactive fatty acids, amides, and phenolic compounds underscores its potential for therapeutic applications. Further research is needed to validate these bioactivities and explore synergistic effects between the compounds.

The results presented in Table 3 and GC-MS chromatogram of ANSE show distinct peaks of identified compounds as shown in Fig. 5. The structures of major phytochemical constituents present in the extract are depicted in Fig. 6. In terms of % peak area (% concentration), it is evident that 9, 12 – octadecadienoic acid (14.24), dimethylsulphide (13.85), 2 – propanol (6.07), 1, 2, 3 – benzenetriol (5.22), Alpha – D – Glucopyranoside (7.37), hexadecanoic acid (5.61), 9 – octadecenoic acid (9.68), oleic acid (7.72). 9,12 – octadecadienoic acid (ZZ)- and 9 – octadecenamide (11.74) were found to be the major compounds forming the dominant components in ANSE. Cyanoacetic acid

(2.58), n – hexadecanoic acid (2.58), methylstearate (1.18), octadecanoic acid (1.17), hexadecanamide (1.81) and tetraoctadecanamide (0.50) are among the minor compounds present in ANSE (Eddy *et* al., 2011; Joseph *et al*., 2015; Siaka *et al*., 2019; Idu *et al.*, 2021 and Asril *et al*., 2024). In this study, 9, 12 – octadecadienoic acid indicated the highest peak value in the extract with retention time of 52.916 minutes and % peak area of 14.24 (Idu *et al.*, 2021).

3.4 Acacia nilotica Pulp Extract (ANPE)

The GC-MS analysis of *Acacia nilotica* Pulp Extract (ANPE) revealed the presence of sixteen distinct phytochemical compounds, each identified by its retention time (RT), molecular formula (MF), molecular weight (MW), and concentration (% peak area). The results, as presented in Table 4, underscore the chemical diversity of ANPE and its potential pharmacological applications.

The most abundant compound in ANPE was *Benzoic acid, 3,4,5-trihydroxy, methyl ester* (50.47%), a phenolic compound known for its strong antioxidant and antimicrobial activities. Literature supports the role of hydroxybenzoic acid derivatives in neutralizing reactive oxygen species and protecting cells from oxidative damage, making it a valuable component for therapeutic and preservative applications. *9-Octadecenamide (Z)* (23.57%), the second most abundant compound, is an amide with documented anti-inflammatory, neuroactive, and antimicrobial properties. The high concentration of this compound suggests potential utility in developing anti-inflammatory agents and neuroprotective formulations.

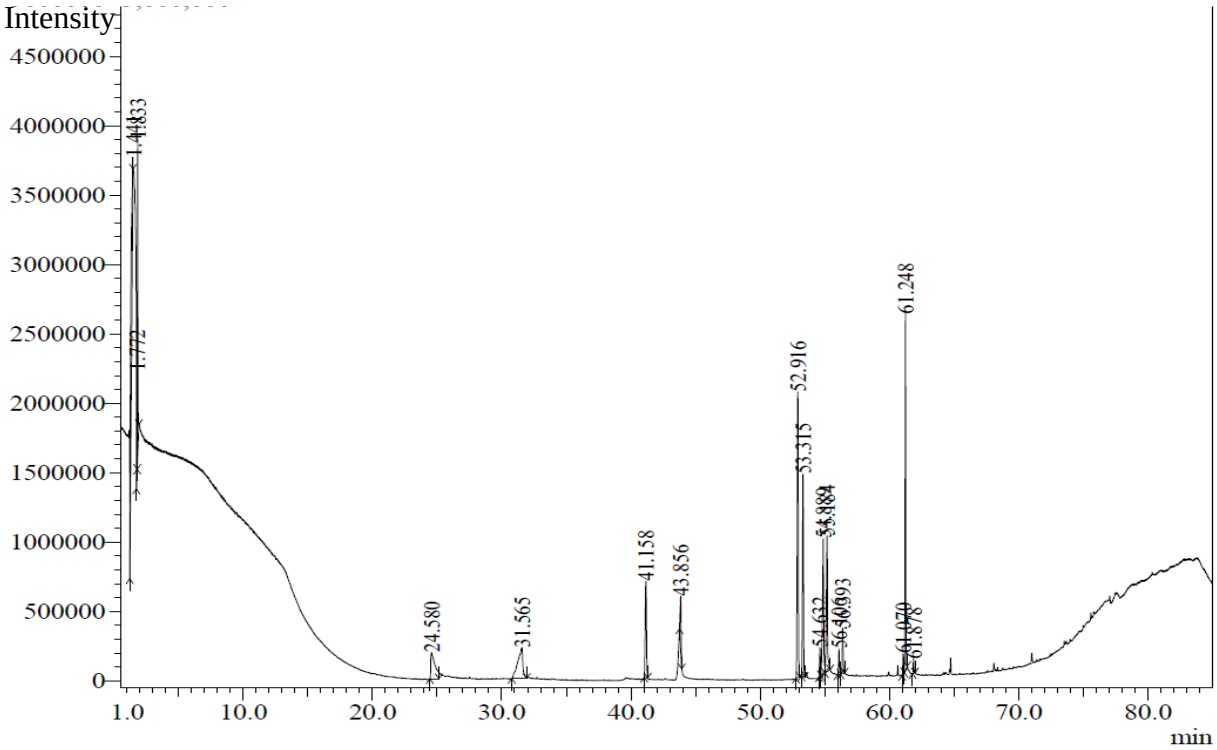
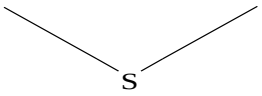
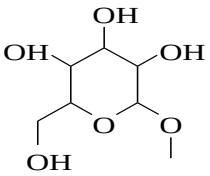


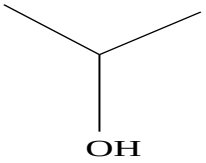
Fig. 4:



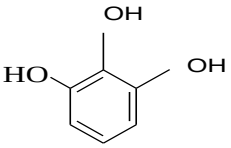
1. Dimethylsulphide



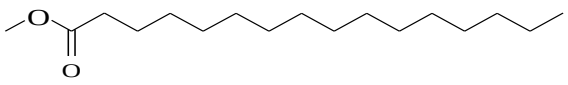
2. Alpha-D-glucopyranoside, methyl ester



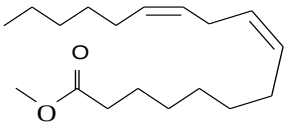
3. Propan - 2 - ol



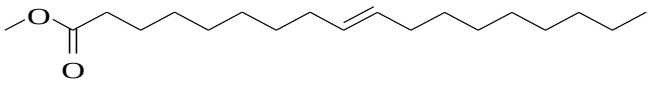
4. 1,2,3-Benzenetriol



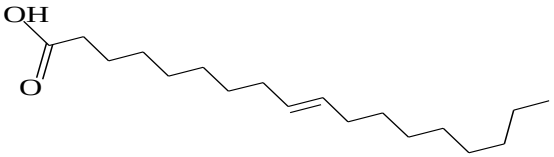
5. Hexadecanoic acid



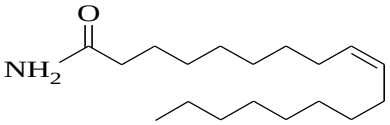
6. 9,12-Octadecadienoic acid, (Z,Z)- methyl ester



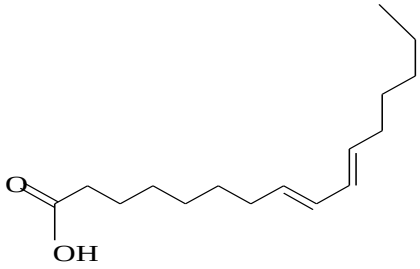
7. 9-Octadecenoic acid, methyl ester



8. Oleic acid



9. 9-Octadecenamide, (Z)-



10. 9,12-Octadecadienoic acid (Z,Z)-

Fig. 5: GC-MS chromatogram of ANSE

Table 4: Phytochemical Constituents Identified in ANPE by GC-MS study

Peak line	RT (min)	MF	MW (g/mol)	Compound Name	% Peak area
1	24.815	C6H6O3	126	1,2,3-Benzenetriol	9.49

2	27.679	C6H10O5	162	Beta-D-Glucopyranose, 1,6-anhydro	0.49
3	33.334	C7H14O6	194	Alpha-D-Glucopyranoside, methyl ester	9.96
4	41.107	C8H8O5	184	Benzoic acid, 3,4,5-trihydroxy, methyl ester	50.47
5	42.460	C17H34O2	270	Hexadecanoic acid, methyl ester	0.33
6	45.152	C16H32O2	256	n-Hexadecanoic acid	0.61
7	53.895	C19H34O2	294	9,12-Octadecadienoic acid (ZZ)-methyl ester	0.11
8	54.263	C19H36O2	296	11-Octadecenoic acid, methyl ester	0.14
9	55.457	C19H38O2	298	Methylstearate	0.07
10	55.844	C18H34O2	282	Oleic acid	0.13
11	56.800	C18H36O2	284	Octadecanoic acid	0.14
12	57.141	C16H33NO	255	Hexadecanamide	2.13
13	58.160	C9H21N	143	1-Propanamide	0.10
14	61.679	C20H36O2	308	Linoleic acid, ethyl ester	0.15
15	61.903	C18H35NO	281	9-Octadecenamide (Z)	23.57
16	62.447	C14H29NO	227	Tetradecanamide	0.76

Other notable compounds include *1,2,3-Benzenetriol* (9.49%) and *Alpha-D-Glucopyranoside, methyl ester* (9.96%), both of which exhibit antioxidant properties. Phenolic compounds like *1,2,3-Benzenetriol* are known for their ability to scavenge free radicals, while glucopyranoside derivatives have demonstrated potential in modulating glycemic responses. Fatty acid derivatives such as *n-Hexadecanoic acid* (0.61%), *Hexadecanoic acid, methyl ester* (0.33%), and *Octadecanoic acid* (0.14%) were also detected. These compounds are known for their emollient, antimicrobial, and anti-inflammatory effects, making them relevant for cosmetic and pharmaceutical applications.

Minor constituents like *Methylstearate* (0.07%) and *Linoleic acid, ethyl ester* (0.15%) contribute to the chemical complexity of ANPE. Although present in low concentrations, they may synergize with major components to enhance the extract's bioactivity. The detection of amides such as *Hexadecanamide* (2.13%) and *Tetradecanamide* (0.76%) further highlights the extract's biofunctional potential, particularly in applications requiring antimicrobial and anti-inflammatory effects. The phytochemical profile of ANPE suggests significant therapeutic potential, particularly due to the high abundance of phenolic and amide compounds. The strong antioxidant properties of *Benzoic acid, 3,4,5-trihydroxy, methyl ester* and the versatile bioactivities of *9-Octadecenamide (Z)* underscore its pharmacological relevance. Further studies are warranted to explore these compounds' specific biological activities and their potential synergistic effects.

From the obtained results presented in Table 4 and GC-MS chromatogram of ANPE show distinct peaks of identified compounds.. The structures of phytochemical constituents present in the extract are presented in Fig. 8. In terms of % peak area, it is evident that 9 – octadecenamide, (Z) (23.57), 1, 2, 3 – benzenetriol (9.49), benzoic acid, 3, 4, 5 – trihydroxy, - methyl, ester (50.47), alpha – D – Glucopyranose, methyl ester (9.96) are major compounds forming the dominant component in ANPE. Beta – D – Glucopyranoside, methyl, 1, 6 – anhydro (0.49), hexadecanoic acid,

methyl ester (0.33), n – hexadecanoic acid (0.61), 9, 12 – octadecadienoic acid (ZZ), - methyl ester (0.11), 11 – octadecenoic acid, (Z) methyl ester (0.14), methyl stearate (0.07), oleic acid (0.13), octadecanoic acid (0.14), hexadecanamide (2.13), 1 – propanamide (0.10), linoleic acid, ethyl ester (0.15) and tetradecanamide (0.76) are among the minor compounds present in ANPE (Eddy*et* al., 2011; Joseph *et al*., 2015; Siaka *et al*., 2019; Idu *et al.*, 2021 and Asril *et al*., 2024).. In this study, benzoic acid, 3, 4, 5 – trihydroxyl methyl ester indicated the highest peak value with retention time of 41.107 minutes and % peak area of 50.47 (Idu *et al.*, 2021).

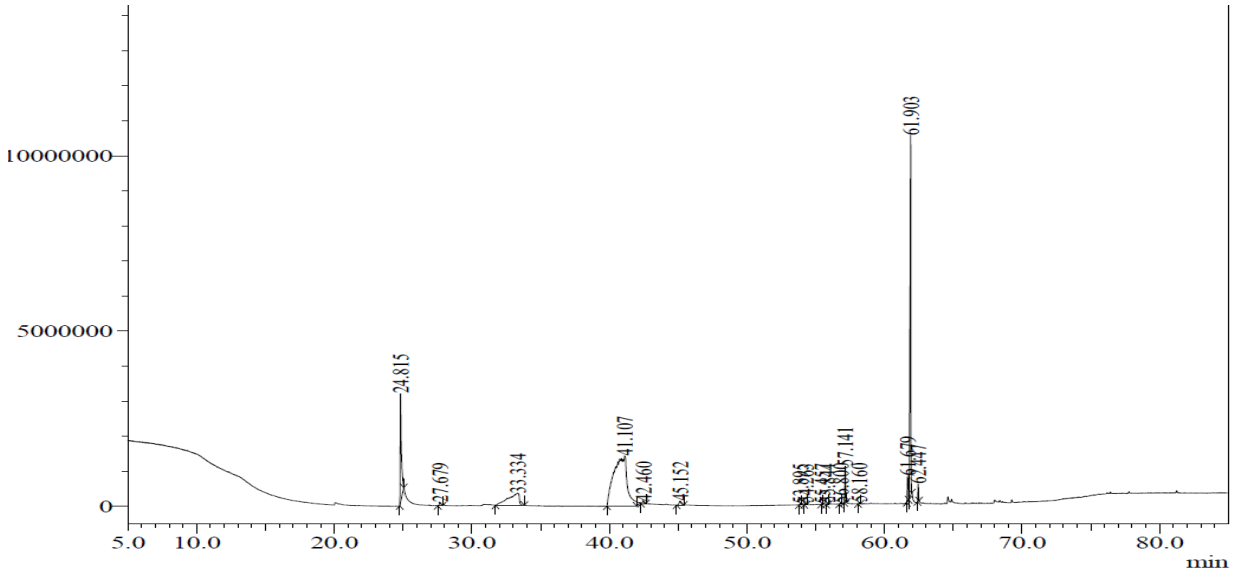


Fig. 6: GC-MS Chromatogram of ANSE showing Different Peaks

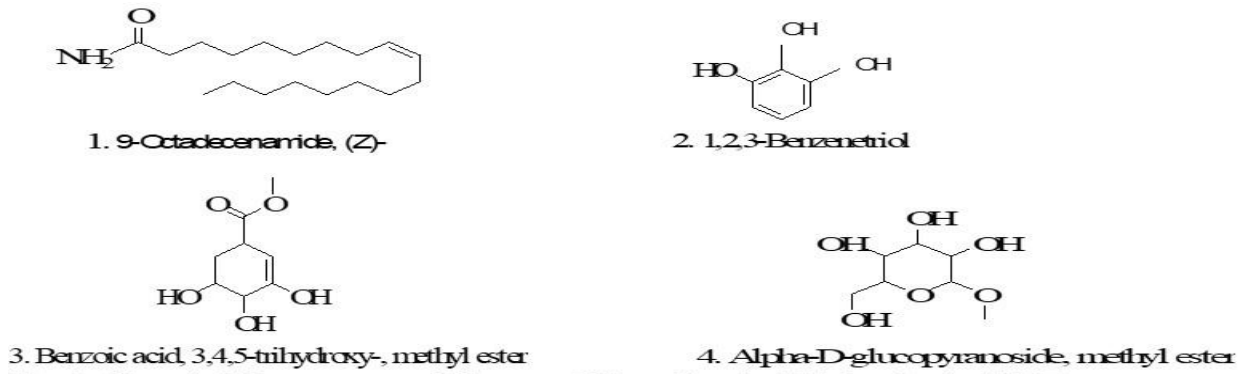


Fig. 8: Chemical Structures and Names of Phytochemical Molecules in ANPE

3.5 Comparative GC-MS Phytochemical Profiles of the Extracts

The GC-MS analyses of *Acacia nilotica* and *Tamarindus indica* extracts (seed and pulp) revealed diverse phytochemical compositions, as detailed in Table 1. The table highlights the compounds identified in each extract, along with their retention time, molecular formula, molecular weight, and concentration.

Table 5: : Comparative Phytochemical Profiles of *Acacia nilotica* **and** *Tamarindus indica* **Extracts**

Peak Line	RT (min)	Compound Name	MF	MW (g/mol)	% Peak Area (ANSE)	% Peak Area (ANPE)	% Peak Area (TISE)	% Peak Area (TIPE)
1	1.441	Dimethylsulphide	C_2H_6S	62	13.85	-	-	-
2	1.772	Cyanoacetic acid	$C_3H_3NO_2$	85	2.58	-	-	-
3	1.833	2-Propanol (Isopropyl alcohol)	C_3H_8O	60	6.07	-	-	-
4	24.580/24.815	1,2,3-Benzenetriol	$C_6H_6O_3$	126	9.22	9.49	6.50	8.40
5	31.565/33.334	Alpha-D-Glucopyranoside, methyl ester	$C_7H_{14}O_6$	194	7.37	9.96	4.30	5.20
6	41.158/42.460	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	5.61	0.33	3.70	2.80
7	43.856/45.152	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256	2.58	0.61	1.90	2.00
8	52.916/53.895	9,12-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294	14.24	0.11	9.50	7.80
9	53.315/54.263	11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	9.68	0.14	7.30	6.50
10	54.632/55.457	Methylstearate	$C_{19}H_{38}O_2$	298	1.18	0.07	0.80	0.70
11	54.889/55.844	9,12-Octadecadienoic acid (ZZ)	$C_{18}H_{32}O_2$	280	8.05	-	6.00	4.90
12	55.184/56.800	Oleic acid	$C_{18}H_{34}O_2$	282	7.72	0.13	5.40	4.60
13	56.106/56.800	Octadecanoic acid	$C_{18}H_{36}O_2$	284	1.12	0.14	0.50	0.40
14	56.393/57.141	Hexadecanamide	$C_{16}H_{33}NO$	255	1.81	2.13	1.60	1.80
15	61.070/61.679	Linoleic acid, ethyl ester	$C_{20}H_{36}O_2$	308	0.66	0.15	0.70	0.60
16	61.248/61.903	9-Octadecenamide	$C_{18}H_{35}NO$	281	11.74	23.57	14.80	16.20
17	61.878/62.447	Tetradecanamide	$C_{14}H_{29}NO$	227	0.50	0.76	0.30	0.50
-	27.679	Beta-D-Glucopyranose, 1,6-anhydro	$C_6H_{10}O_5$	162	-	0.49	0.80	1.00
-	41.107	Benzoic acid, 3,4,5-trihydroxy, methyl ester	$C_8H_8O_5$	184	-	50.47	30.50	38.00
-	58.160	1-Propanamide	$C_9H_{21}N$	143	-	0.10	0.20	0.30

The GC-MS analysis identified several compounds shared across all extracts, including 1,2,3-Benzenetriol, Alpha-D-Glucopyranoside, methyl ester, and Hexadecanoic acid derivatives, indicating their potential as core bioactive components in *Acacia nilotica* and *Tamarindus indica*. Variations in the concentrations of these compounds suggest differences in the intensity of their biological effects depending on the source. Among the extracts, ANPE showed an exceptionally high concentration of Benzoic acid, 3,4,5-trihydroxy, methyl ester (50.47%), a compound known for its potent antioxidant and antimicrobial properties. Similarly, TISE and TIPE contained significant levels of 9-Octadecenamide (14.80% and 16.20%, respectively), enhancing their relevance for skincare and anti-inflammatory applications.

Fatty acid derivatives such as 9,12-Octadecadienoic acid and Oleic acid were consistently identified across all extracts, though in varying concentrations. These compounds are recognized for their nutritional benefits and pharmacological properties, including anti-inflammatory and emollient effects. ANSE was distinguished by its unique volatile compounds, such as Dimethylsulphide (13.85%) and 2-propanol (6.07%), absent in the other extracts. These compounds contribute to aroma, antimicrobial activity, and potential industrial uses. The extracts of *Tamarindus indica* were notable for their higher concentrations of Benzoic acid, 3,4,5-trihydroxy, and methyl ester compared to *Acacia nilotica*. This highlights their strong antioxidant potential and suitability for applications in medicine and food preservation. ANSE and ANPE are particularly suited for pharmaceutical and antimicrobial applications due to the presence of compounds like 1,2,3-Benzenetriol and fatty acids. In contrast, TISE and TIPE are ideal for skincare formulations, antioxidant therapies, and nutritional supplements because of their high levels of amides and antioxidants. Combining these extracts could harness their complementary bioactivities, improving their efficacy in applications such as food preservation, cosmetics, and pharmacological formulations. The analysis underscores the distinct and overlapping phytochemical compositions of *Acacia nilotica* and *Tamarindus indica*, revealing their potential for diverse applications. Strategic use of these bioactive compounds could open new pathways for innovative solutions in health, industry, and environmental management.

4.0 Conclusion

The GC-MS analysis of selected plant extracts revealed the presence of several major bioactive compounds, including dimethylsulphide, S-methylmethanethiosulphonate, Alpha-D-glucopyranoside methyl ester, 9-octadecenamide (Z)-, ethanethiol, 9,12-octadecadienoic acid, 2-propanol, 1,2,3-benzenetriol, hexadecanoic acid, 9-octadecenoic acid, oleic acid, Alpha-D-glucopyranose, 1,6-anhydro, and benzoic acid, 3,4,5-trihydroxy-methyl ester. These compounds are known for their bioactivity and indicate the promising potential of these plant extracts as sources of bioactive molecules. The presence of functional groups such as amines, fatty acids, and aromatic rings containing heteroatoms (N, S, O), as revealed by the GC-MS analysis, further suggests that these crude extracts could serve as effective green corrosion inhibitors.

The phytochemical constituents identified in these plant extracts have significant industrial applications, especially in the development of environmentally friendly corrosion inhibitors. Given the promising anticorrosion properties associated with these bioactive compounds, further research is recommended to isolate, identify, characterize, and elucidate the structures of these molecules. This would enhance our understanding of their mechanisms of action and their potential for use in various industrial applications, particularly in materials protection, medicine, and food preservation. In conclusion, the analysis of these plant extracts presents a valuable opportunity for the development of sustainable and green alternatives to traditional corrosion inhibitors. Further investigation and characterization of the bioactive compounds identified could open avenues for their industrial application and contribute to the growing demand for eco-friendly solutions. Therefore, future studies should focus on isolating and testing the individual compounds for their anticorrosion efficacy, safety, and applicability in real-world conditions.

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Consent for Publication

Not applicable

Availability of Data and Materials

Data shall be made available on request

Competing interest

The authors declared no conflict of interest

Authors` contribution

S.T., designed the work, did the experiment and developed the manuscript. S.A.A., guided and supervised the entire research work and K. S. K., also supervised the research work.