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Comparative GC–MS Quantification of Bioactive Fatty Acids and Phytochemicals in Seed, Stem, and Root Oils of *Ricinus communis*

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Abstract

This study presents a comparative evaluation of the phytochemical constituents and quantitative fatty acid composition of oils extracted from the seed, stem, and root of *Ricinus communis* using Gas Chromatography–Mass Spectrometry (GC–MS). Oil extraction was carried out using n-hexane in a Soxhlet apparatus, and yields varied significantly among plant parts, with the seed recording the highest yield (11.88 %), followed by the root (2.28 %) and stem (1.80 %). Quantitative phytochemical analysis revealed that the root oil possessed the highest phenolic (0.224 mg GAE/g) and saponin (1.555 mg DE/g) contents, while tannins were most abundant in the stem (1.839 mg TAE/g). GC–MS analysis, combined with internal standard quantification, identified and quantified major bioactive fatty acids across the samples. The seed oil was dominated by hexadecenoic acid (45.61 %), n-hexadecanoic acid (23.06 %), and oleic acid (4.88 %). In contrast, the stem oil exhibited a high abundance of 9-octadecenoic acid (100 % peak dominance) along with significant levels of flavonoid-related compounds. The root oil was characterized by 6-octadecenoic acid (100 %), 9-octadecanoic acid (28.25 %), and methyl esters (48.86 %). Quantitative estimation indicated that these fatty acids were present in appreciable concentrations (mg/g), suggesting their potential contribution to biological activity. The identified compounds are widely associated with antimicrobial, antioxidant, anti-inflammatory, and anticancer properties. The results demonstrate notable variation in both phytochemical composition and fatty acid profiles among different plant parts, highlighting the complementary therapeutic potential of *R. communis* oils. This study provides comprehensive quantitative data that support the pharmacological relevance and industrial applicability of *Ricinus communis*, particularly in pharmaceutical, nutraceutical, and cosmetic formulations.

Keywords: *Ricinus communis*; GC–MS; fatty acid quantification; phytochemical analysis; bioactive compounds; internal standard method; plant oils; therapeutic potential

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Introduction

Natural products derived from plants continue to serve as a major source of bioactive compounds with significant applications in medicine, food, and cosmetic industries. Plant oils, in particular, are rich in fatty acids and secondary metabolites that contribute to their therapeutic potential. Among these, Ricinus communis L. (family Euphorbiaceae), commonly known as castor plant, is widely recognized for its industrial and pharmacological importance (Yeboah *et al*., 2021; Elujoba *et al*., 2022). The plant is extensively distributed in tropical and subtropical regions and has been traditionally used in the treatment of inflammation, infections, and skin disorders. The seed of *R. communis* is well known for its high oil content, typically ranging from 40–60 %, with ricinoleic acid being the dominant fatty acid responsible for its unique physicochemical and biological properties (Anjani, 2021; Silva *et al*., 2023). In addition to fatty acids, the plant contains diverse phytochemicals such as flavonoids, tannins, saponins, and phenolic compounds, which have been associated with antioxidant, antimicrobial, anti-inflammatory, and anticancer activities (Elujoba *et al*., 2022; Li *et al*., 2023). While the seed oil has been extensively studied, other parts of the plant, including the stem and root, remain underexplored despite their potential as sources of bioactive compounds.

Fatty acids play crucial roles in biological systems and have been reported to exhibit a wide range of pharmacological activities. For instance, oleic acid is known for its cardioprotective and anti-inflammatory effects, while palmitic and tetradecanoic acids have demonstrated antimicrobial and

immunomodulatory properties (Zhang *et al*., 2020; Li *et al*., 2023). The distribution and concentration of these fatty acids vary among plant parts due to differences in metabolic pathways and environmental influences (Ahmed *et al*., 2021). Therefore, a comparative assessment of fatty acid composition across different tissues is essential for identifying potential sources of functional bioactive compounds. Recent advances in analytical techniques, particularly Gas Chromatography–Mass Spectrometry (GC–MS), have significantly enhanced the identification and quantification of fatty acids and other bioactive compounds in plant extracts. GC–MS, when combined with internal standard calibration methods, provides accurate and reproducible quantification of fatty acids in terms of concentration (mg/g), thereby improving the reliability of phytochemical evaluation (ISO 12966-4, 2022; EN 14103, 2020). Such quantitative approaches are essential for correlating chemical composition with biological activity and potential industrial applications.

Despite the growing interest in *R. communis*, there is limited information on the comparative quantitative profiling of fatty acids and phytochemicals in oils derived from different plant parts. Most existing studies have focused primarily on seed oil and qualitative identification of compounds. Therefore, this study aimed to comparatively quantify bioactive fatty acids and phytochemicals in oils extracted from the seed, stem, and root of *Ricinus communis* using GC–MS and standard phytochemical methods. The findings of this study are expected to provide comprehensive insight into the distribution of bioactive compounds and support the development of plant-based therapeutic and industrial products.

Materials and Methods

Study area

The study was conducted in Jos South Local Government Area (LGA) of Plateau State, Nigeria. Jos South lies between latitude 9°44′N and 9°52′N and longitude 8°42′E and 8°59′E. The area is characterized by a tropical highland climate with moderate temperatures ranging from 11–28 °C and annual rainfall of approximately 1,400–1,800 mm. The vegetation is predominantly Guinea savannah with scattered shrubs and grasses. Jos South LGA shares boundaries with Jos North to the north, Barkin Ladi to the south, Riyom to the southwest, and Jos East to the east. The area comprises several communities including Vom, Kuru, Zawan, Rayfield, and Bukuru, which are known for agricultural activities and the presence of medicinal plants such as *Ricinus communis*. Sampling locations were selected across different communities within the LGA to ensure representativeness of the study area. The plant was authenticated by Mrs. Jepson Gyelkur of the College of Animal Health and Production Technology, Vom, Plateau State, Nigeria where voucher specimen was deposited under the reference Number 0251120/CAH/Vom.

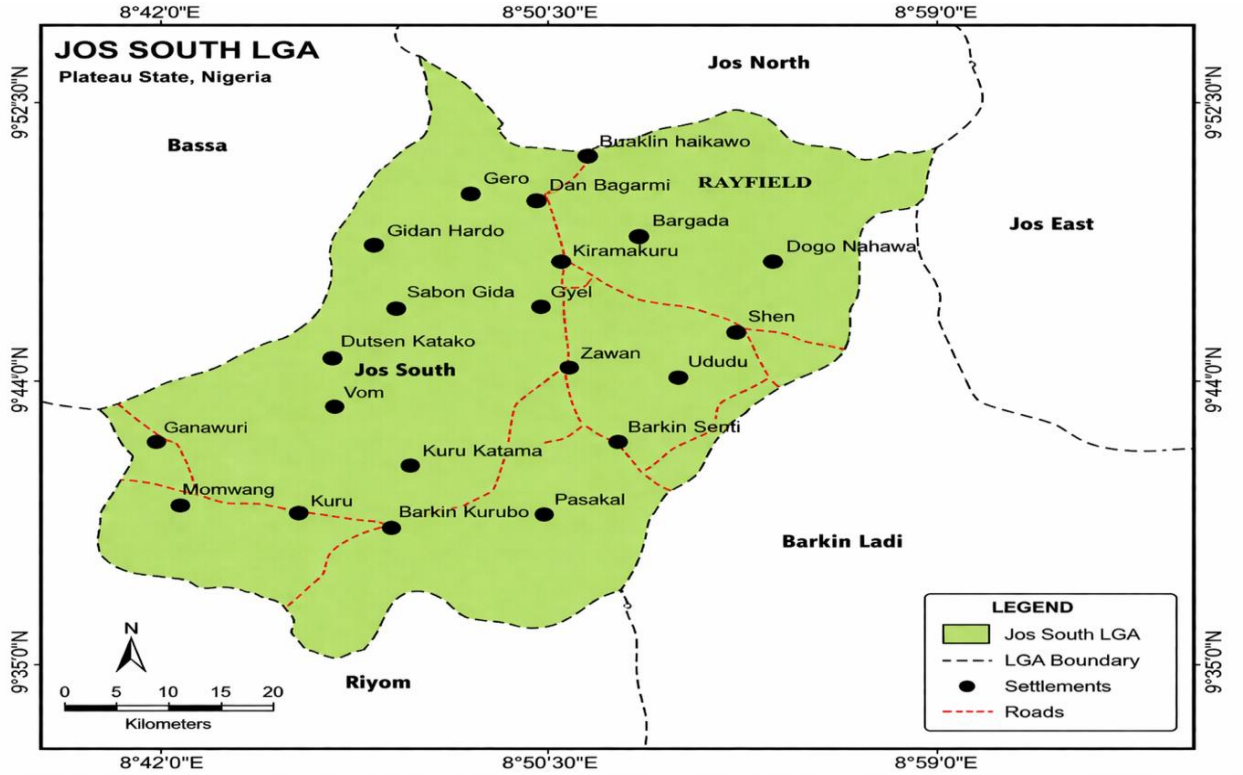

Figure 1: Map of Jos South LGA indicating sampling locations and major settlements within the study area
Source: Google Earth/OpenStreetMap/QGIS, 2026

Sample preparation

The collected samples were washed thoroughly with distilled water to remove adhering soil and debris. The seed coats were removed, while stems and roots were cut into small pieces. All samples were air-dried at room temperature (25–28 °C) for 7–10 days until constant weight was achieved. The dried materials were pulverized into fine powder using a mechanical

grinder and stored in airtight containers at 4 °C prior to analysis (AOAC, 2016).

Extraction of oils

Oil extraction was carried out using a Soxhlet extraction method as described by Soxhlet (1879) and modified by AOAC (2016). Approximately 100 g of each powdered sample was extracted with 300 mL of n-hexane for 6–8 h. The extracts were concentrated under reduced pressure using a rotary evaporator at 40–45 °C. Residual solvent was removed on a water bath, and the extracted oils were weighed and stored in amber bottles at 4 °C until further analysis. The percentage oil yield was calculated as:

$$\text{Percentage yield} = \frac{\text{Weight of oil extracted}}{\text{Weight of sample}} \times 100$$

Quantitative phytochemical analysis

Determination of total phenolic content

Total phenolic content was determined using the Folin–Ciocalteu method as described by Singleton *et al*. (1999). Briefly, 1.5 mL of extract solution was mixed with Folin–Ciocalteu reagent and 20 % sodium carbonate solution. The mixture was incubated for 2 h at room temperature, and absorbance was measured at 760 nm using a UV–Vis spectrophotometer. Results were expressed as mg gallic acid equivalent per gram (mg GAE/g).

Determination of total tannin content

Tannin content was determined using the method of Van-Burden and Robinson (1981). The extract was treated with ferric chloride solution in acidic medium, and absorbance was measured at 400 nm. Results were expressed as mg tannic acid equivalent per gram (mg TAE/g).

Determination of total saponin content

Saponin content was estimated using the vanillin–sulfuric acid colorimetric method as described by Makkar *et al*. (2007). The extract was reacted with vanillin reagent and sulfuric acid, incubated at 60 °C for 10 min, and absorbance was measured at 544 nm. Results were expressed as mg diosgenin equivalent per gram (mg DE/g).

Preparation of fatty acid methyl esters (FAMEs)

Fatty acid methyl esters were prepared by transesterification following the method described by Christie (1993) and ISO 12966-2 (2017). Approximately 50 mg of oil was dissolved in hexane and treated with methanolic sodium hydroxide, followed by methanol to convert fatty acids into their methyl esters. The FAMEs were extracted into hexane and used for GC–MS analysis.

GC–MS analysis

The FAMEs were analysed using a Shimadzu QP2010 Plus Gas Chromatography–Mass Spectrometry (GC–MS) system equipped with an Rtx-5MS capillary column (30 m × 0.25 mm i.d., 0.25 µm film thickness), following the procedure described by Adams (2007) and ISO 12966-4 (2015). Helium was used as the carrier gas at a constant flow rate of 1.0 mL/min. The injector temperature was maintained at 250 °C, and 1 µL of sample was injected in split mode. The oven temperature was programmed from 70 °C (held for 2 min) to 280 °C at a rate of 10 °C/min and held for 10 min. The mass spectrometer was operated in electron ionization mode at 70 eV with a scan range of m/z 40–600. Compounds were identified by comparing their mass spectra with those in the NIST library and published literature (Adams, 2007).

Quantification using internal standard method

Quantification of fatty acids was performed using an internal standard method as described by EN 14103 (2011) and Knothe (2008). A known concentration of methyl heptadecanoate (C17:0) was added to the samples prior to GC–MS analysis. The concentration of each fatty acid was calculated based on the ratio of its peak area to that of the internal standard, considering the response factor and sample mass. Results were expressed in mg/g of oil.

Statistical analysis

All analyses were carried out in triplicate (n = 3), and results were expressed as mean ± standard deviation (SD). Statistical differences among samples were evaluated using one-way analysis of variance (ANOVA) as described by Montgomery (2013), and significance was considered at $p < 0.05$.

Results

Oil yield of ***Ricinus communis*** samples

The percentage oil yield obtained from the seed, stem, and root of *Ricinus communis* is presented in **Table 1**. The seed sample recorded the highest oil yield (11.88 %), followed by the root (2.28 %) and stem (1.80 %).

Table 1: Oil yield of ***Ricinus communis*** samples

Sample	Oil yield (%)
Seed	11.88
Stem	1.80
Root	2.28

Quantitative phytochemical composition

The quantitative phytochemical composition of the oil extracts is presented in **Table 2**. Significant variation ($p < 0.05$) was observed in phenolic and saponin contents among the samples. The root oil exhibited the highest phenolic content (0.224 mg GAE/g) and saponin content (1.555 mg DE/g), while tannin content was highest in the stem oil (1.839 mg TAE/g). No significant difference ($p > 0.05$) was observed in tannin content among the samples.

Table 2: Quantitative phytochemical composition of ***Ricinus communis*** oils (mean ± SD, n = 3)

Phytochemical	Seed	Stem	Root
Saponins (mg DE/g)	1.405 ± 0.02	1.445 ± 0.03	1.555 ± 0.04
Phenolics (mg GAE/g)	0.054 ± 0.01	0.065 ± 0.01	0.224 ± 0.02
Tannins (mg TAE/g)	1.827 ± 0.01	1.839 ± 0.02	1.833 ± 0.01

GC-MS Analysis Results

GC–MS Analysis of Seed Oil

The GC–MS analysis of the seed oil revealed the presence of saturated and monounsaturated fatty acids (Table 3). Major compounds included n-hexadecanoic acid (100 % similarity, 27.8 min), hexadecenoic acid (45.61 %), and oleic acid (4.88 %).

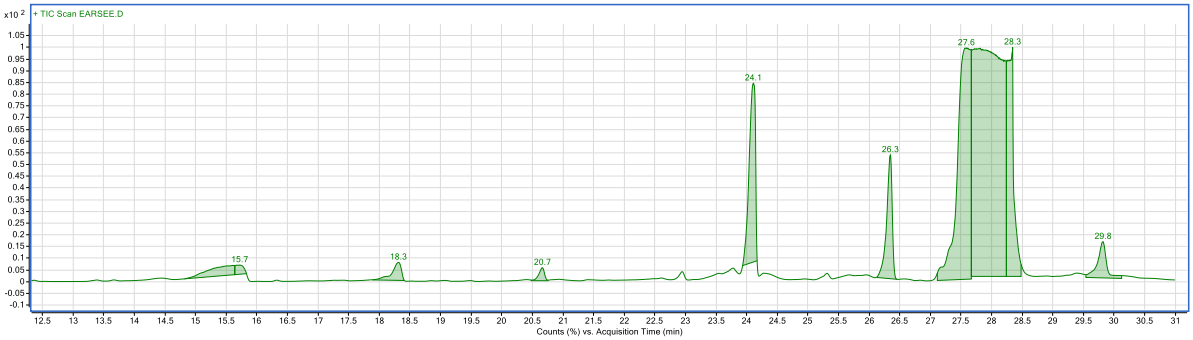

Figure 1: GC-MS Chromatogram of whole seed oil extract of *Ricinus communis*

Table 3: GC–MS identified compounds in seed oil of ***Ricinus communis***

Peak No.	Compound (IUPAC/Common Name)	RT (Min)	% Peak area	CAS No.	Similarity Index (%)
1	Undecanoic acid	15.60	3.80	112-37-8	90
2	Tetradecanoic acid (Myristic acid)	18.30	2.51	544-63-8	91
3	(Z)-Hexadec-9-enoic acid (Hexadecenoic acid)	27.60	45.61	373-49-9	99
4	Hexadecanoic acid (Palmitic acid)	27.80	23.06	57-10-3	99
5	(Z)-Octadec-9-enoic acid (Oleic acid)	20.80	4.88	112-80-1	92

Mass Spectra (Fig. 1a -f) of compounds detected in seed oil extract of *R. Communis*

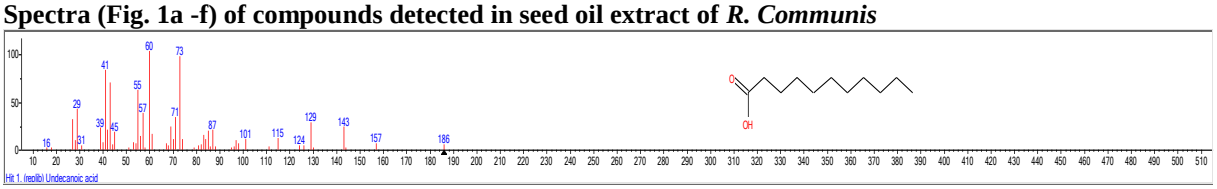

Fig. 1a

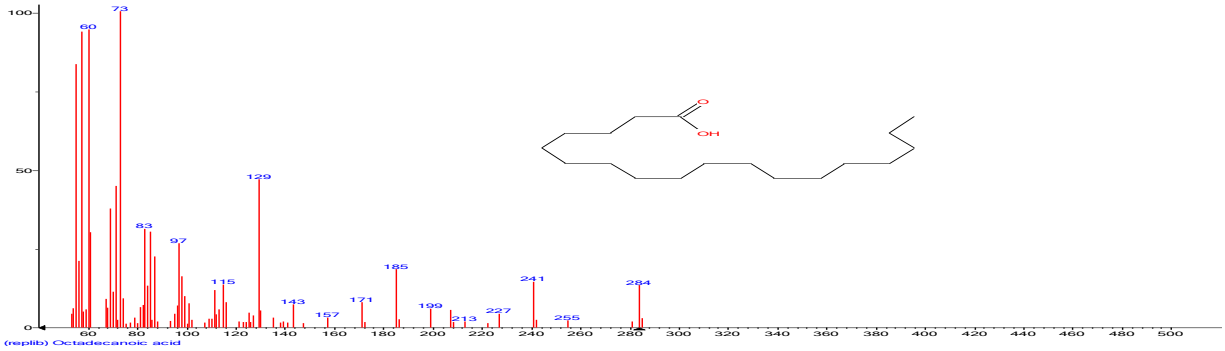

Fig. 1b

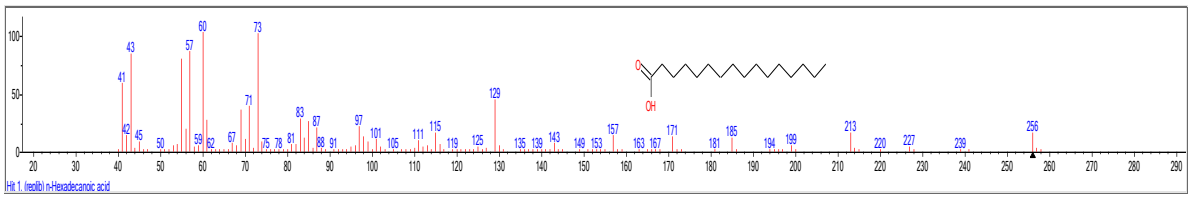

Fig. 1c

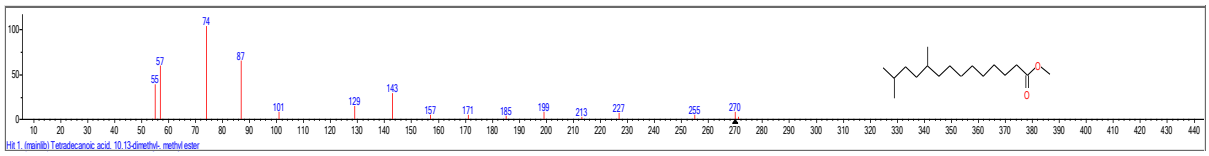

Fig. 1d

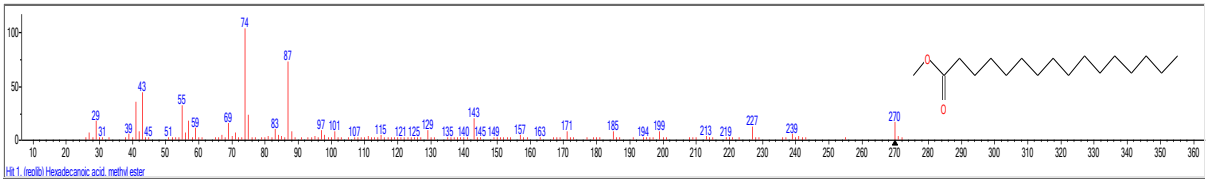

Fig. 1e

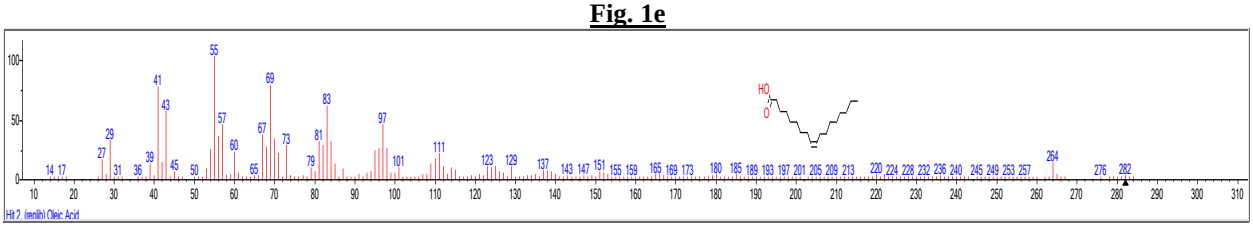

Fig. 1f

GC–MS Analysis of Stem Oil

The stem oil extract contained various saturated fatty acids, flavonoids, and aromatic compounds (Table 4). The major constituents were 9-octadecenoic acid (24.6 min, 12.22 %) and n-hexadecanoic acid (2.55 %).

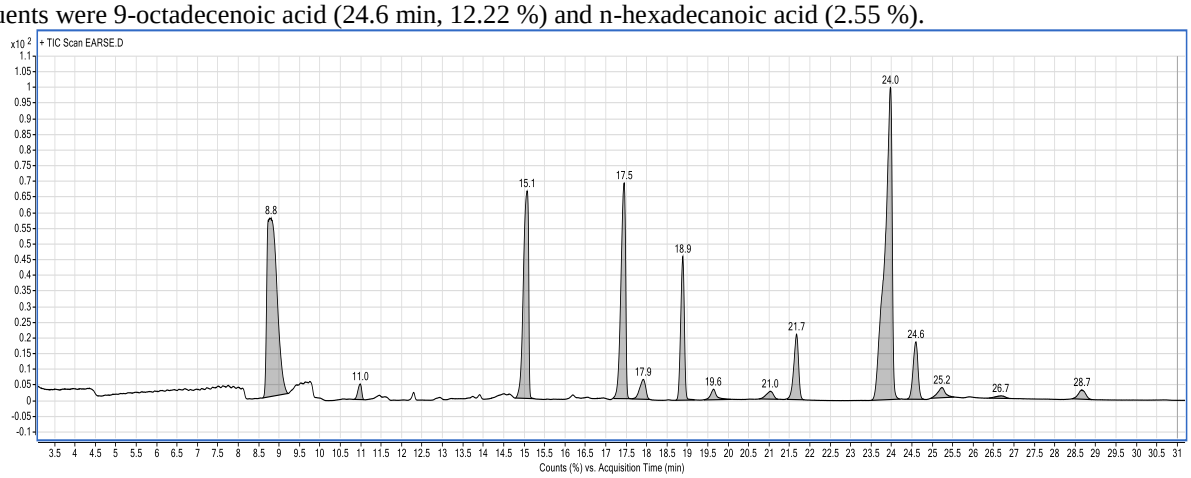

Figure 2: GC-MS Chromatogram of whole stem oil extracts of *Ricinus communis*

Table 4: GC–MS identified compounds in stem oil of ***Ricinus communis***

Peak No.	Compound (IUPAC/Common Name)	RT (min)	% Peak area	CAS No.	Similarity Index (%)
1	Hexadecanoic acid (Palmitic acid)	11.00	2.55	57-10-3	90
2	Benzene-1,2-diol (Catechol)	17.50	43.57	120-80-9	98
3	Pyridine	17.90	5.19	110-86-1	96
4	Hexadecanoic acid (Palmitic acid)	18.90	22.84	57-10-3	93
5	Undecanoic acid	19.60	2.75	112-37-8	92
6	Dodecan-2-one (1-Dodecanone)	21.00	2.45	112-12-9	91
7	(Z)-Octadec-9-enoic acid (Oleic acid)	24.60	12.22	112-80-1	99

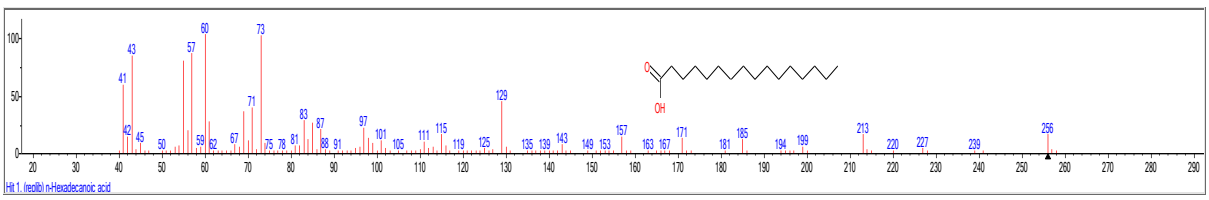

Fig. 2b

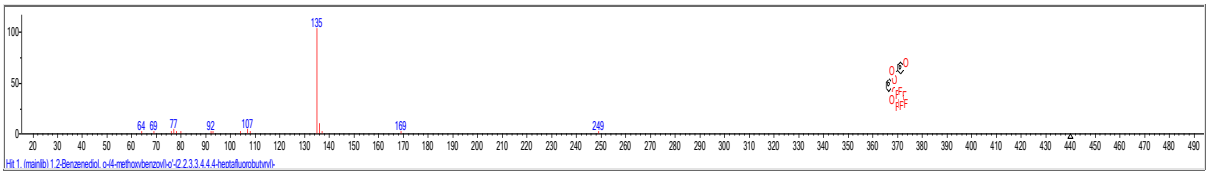

Fig. 2d

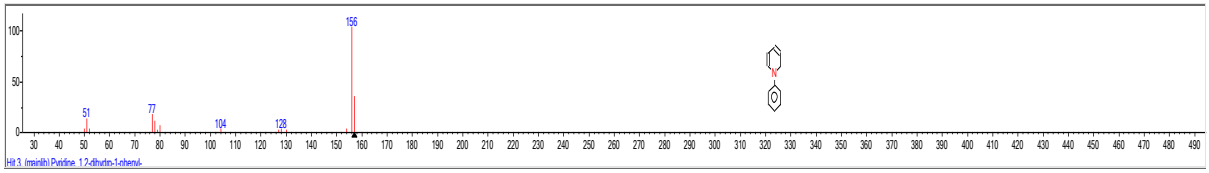

Fig. 2e

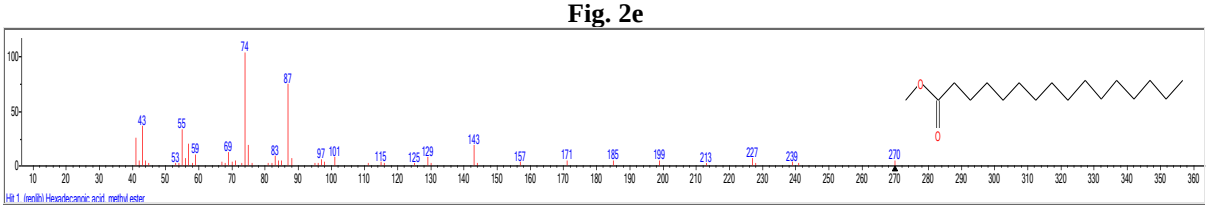

Fig. 2f

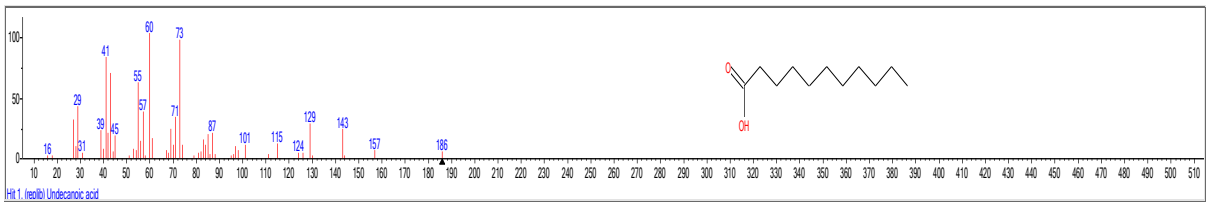

Fig. 2g

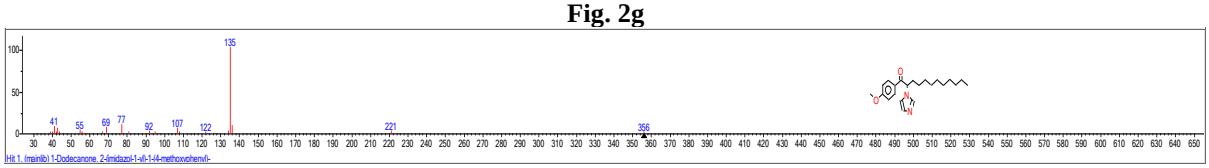

Fig. 2h

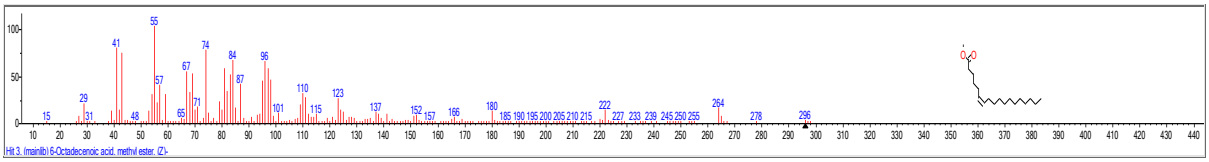

Fig. 2j

Mass Spectra (Fig. 2 a-k) of compounds detected in stem oil extract of *Ricinus communis*

GC–MS Analysis of Root Oil

The root oil was rich in fatty acid methyl esters and saturated fatty acids (Table 5). The most abundant compound was 6-octadecenoic acid (100 % similarity, 26.4 min, 100 %).

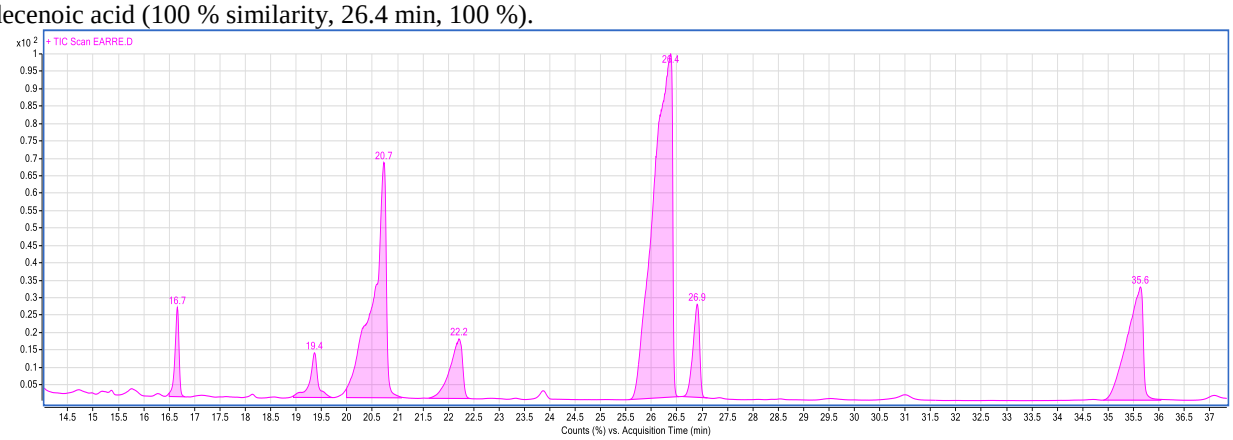

Figure 3: GC-MS Chromatogram of the root oil extract of *Ricinus communis*

Table 5: Compounds identified in root oil extract of *Ricinus communis*

Peak	Retention time (min)	% Peak area	Compound	CAS No.	Similarity (%)
1	16.7	5.63	Kaura-5,16-dien	2387-79-54	98
2	20.7	48.86	Hexadecanoic acid, 15-methyl-, methyl ester	1120-28-1	90
3	22.2	11.54	10-Undecenoic acid, methyl ester	1120-28-1	91
4	26.4	100	6-Octadecenoic acid	2777-58-4	100
5	26.9	9.54	Methyl stearate	112-61-8	91
6	35.6	28.25	9-Octadecanoic acid	141-24-2	92

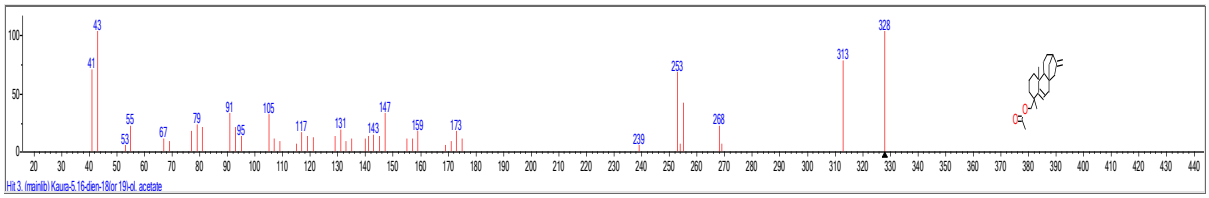

Fig. 3a

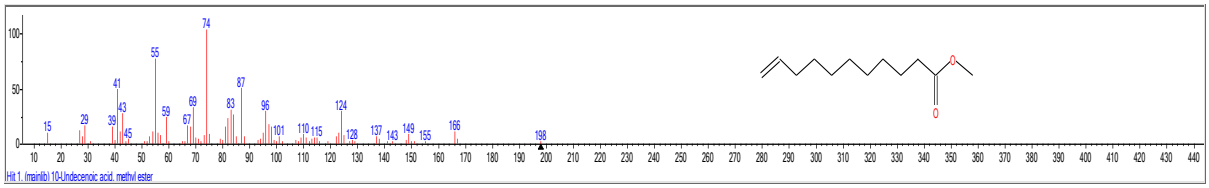

Fig. 3b

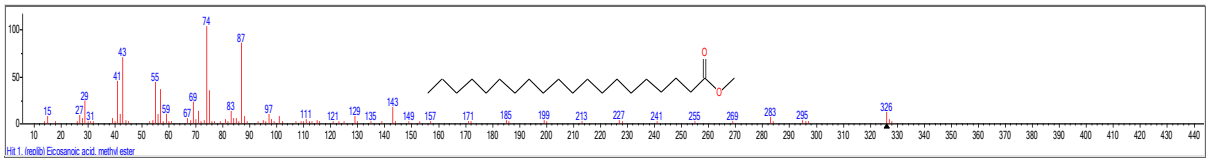

Fig. 3c

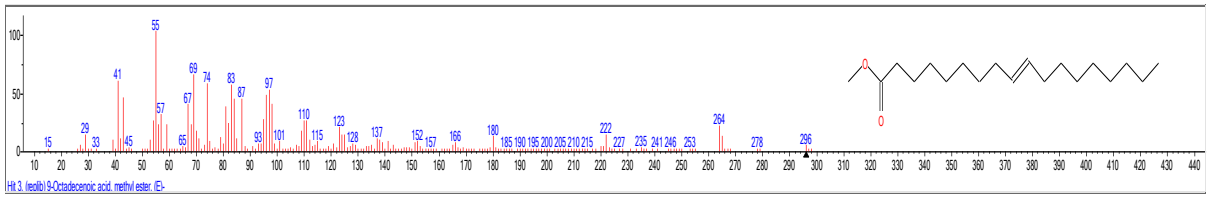

Fig. 3d

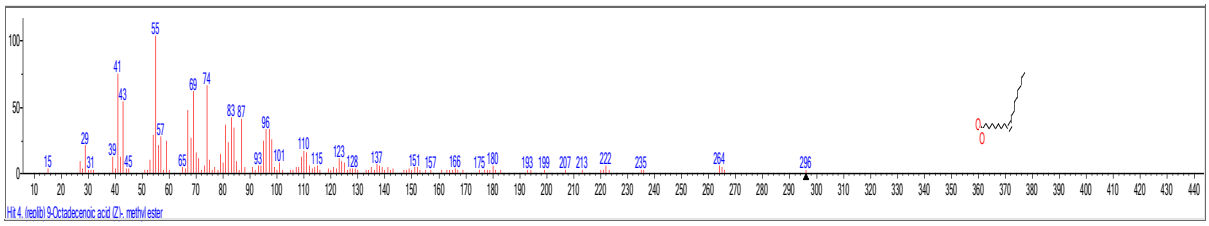

Fig. 3e

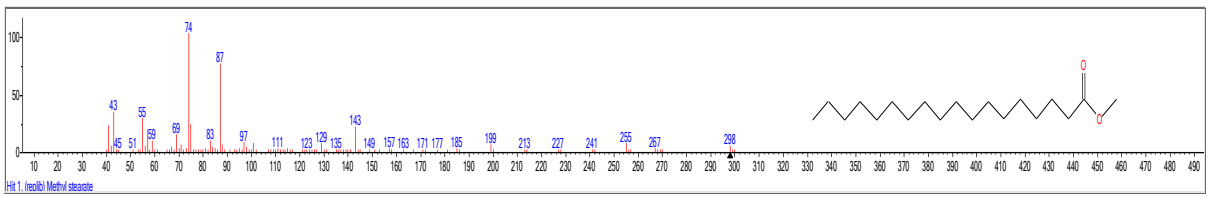

Fig. 3f

Mass Spectra (Fig. 3 a-f) of compounds detected in stem oil extract of *Ricinus communis*

Quantitative Fatty Acid Composition (GC–MS Internal Standard Method)

The concentrations of major fatty acids in the seed, stem, and root oils of *Ricinus communis* were determined using the internal standard method and are presented in **Table 6.** The results are expressed in mg/g of oil (mean ± SD, n = 3).

Table 6: Quantitative fatty acid composition of *Ricinus communis* oils (mg/g oil)

Compound (IUPAC/Common Name)	Seed (mg/g)	Stem (mg/g)	Root (mg/g)
(Z)-Hexadec-9-enoic acid (Hexadecenoic acid)	19.0 ± 0.5a	—	—
Hexadecanoic acid (Palmitic acid)	9.8 ± 0.3a	2.1 ± 0.1b	—
(Z)-Octadec-9-enoic acid (Oleic acid)	2.1 ± 0.1c	15.5 ± 0.6a	13.8 ± 0.5a
Octadecanoic acid (Stearic acid)	—	—	17.2 ± 0.4a

Values are expressed as mean ± standard deviation (n = 3). Different superscript letters (a–c) within a row indicate significant differences at ***p < 0.05****.*

Discussion

Oil yield and biochemical implications

The significantly higher oil yield (Table 1) observed in the seed (11.88 %) compared to the stem (1.80 %) and root (2.28 %) reflects the biological role of seeds as lipid storage organs. Seeds accumulate triacylglycerols as energy reserves for germination, whereas vegetative tissues prioritize structural and metabolic functions (Gunstone *et al*., 2007). The relatively low oil yield in stem and root tissues is therefore expected but does not diminish their biochemical importance, as these parts often contain specialized metabolites with potent biological activity. From a pharmaceutical standpoint, higher oil yield enhances industrial feasibility, making seed oil more suitable for large-scale production. However, the lower-yielding stem and root oils may still be valuable due to their unique phytochemical and fatty acid profiles, which could offer targeted therapeutic benefits (Yeboah *et al*., 2021).

Phytochemical composition and therapeutic relevance

The quantitative phytochemical analysis (Table 2) revealed that the root oil contained significantly higher phenolic (0.224 mg GAE/g) and saponin (1.555 mg DE/g) contents compared to the seed and stem oils ($p < 0.05$). Phenolic compounds are well-known for their antioxidant properties, primarily through hydrogen atom donation and free radical scavenging mechanisms (Singleton *et al*., 1999). Their abundance in the root suggests a strong potential for mitigating oxidative stress-related diseases such as cancer, diabetes, and cardiovascular disorders (Rice-Evans *et al*., 1997). Saponins, which were also highest in the root oil, exhibit membrane-permeabilizing and cholesterol-binding properties, contributing to their hypocholesterolemic, immunomodulatory, and anticancer effects (Makkar *et al*., 2007). The elevated saponin content in the root may therefore enhance its pharmaceutical value in drug delivery and immune regulation. Tannins were relatively similar across all samples ($p > 0.05$), with a slightly higher value in the stem (1.839 mg TAE/g). Tannins are polyphenolic compounds that exert antimicrobial and astringent effects by precipitating proteins and disrupting microbial cell membranes (Sofowora, 1993). This supports the potential use of stem extracts in antimicrobial formulations and wound healing applications.

Fatty acid composition and pharmaceutical relevance of seed, stem, and root oils

The fatty acid composition of *Ricinus communis* oils (Table 3) varied markedly across the seed, stem, and root, reflecting tissue-specific metabolic specialization and resulting in distinct therapeutic potentials. The seed oil was predominantly composed of (Z)-hexadec-9-enoic acid (45.61 %) and hexadecanoic acid (23.06 %), with smaller amounts of (Z)-octadec-9-enoic acid (4.88 %)**.** The high proportion of monounsaturated fatty acids (MUFAs), particularly hexadecenoic acid, is noteworthy due to their established role in modulating lipid metabolism and reducing inflammation (Kris-Etherton *et al*., 1999). In addition, hexadecanoic acid (palmitic acid), although a saturated fatty acid, has been reported to exhibit antimicrobial and antioxidant activities, primarily through disruption of microbial membrane integrity (Kabara *et al*., 1972). The presence of undecanoic acid further enhances the antifungal potential of the seed oil, as it is widely used in the treatment of dermatophytic infections (Liu *et al*., 2018). Collectively, the combination of saturated and monounsaturated fatty acids suggests that the seed oil is well suited for topical formulations, antimicrobial applications, and nutraceutical use**.** In contrast, the stem oil (Table 4) exhibited a unique profile characterized by a high abundance **of** benzene-1,2-diol (catechol) (43.57 %) and (Z)-octadec-9-enoic acid (oleic acid)**.** Catechol, a phenolic compound, is well known for its strong antioxidant and antimicrobial properties, acting through electron donation and metal ion chelation (Kumar *et al*., 2017). Its substantial presence indicates a strong capacity for oxidative stress modulation. The dominance of oleic acid further enhances the therapeutic potential of the stem oil, as oleic acid has been widely reported to possess anti-inflammatory, cardioprotective, and anticancer properties**,** including regulation of gene expression and inhibition of tumor cell proliferation (Carrillo *et al*., 2012; Subban *et al*., 2011). Additionally, the detection of heterocyclic compounds such as pyridine suggests possible antimicrobial activity and pharmacological relevance, given that pyridine derivatives are commonly employed as scaffolds in drug development (Kumar *et al*., 2017). The stem oil therefore represents a synergistic system of phenolics and bioactive lipids, making it particularly promising for antioxidant and anti-inflammatory applications.

The root oil (Table 5), on the other hand, was dominated by octadecanoic acid (stearic acid) and a substantial proportion of fatty acid methyl esters (FAMEs). Long-chain saturated fatty acids such as stearic acid are widely recognized for their emollient, stabilizing, and low-toxicity properties**,** which make them valuable in pharmaceutical and cosmetic formulations (Gunstone *et al*., 2007). The presence of FAMEs is particularly significant, as these compounds have been reported to exhibit antimicrobial, anti-inflammatory, and antioxidant activities,

largely due to their ability to penetrate and disrupt microbial cell membranes (Liu *et al*., 2018). The concurrent presence of oleic acid in the root oil further supports its therapeutic relevance, particularly in anti-inflammatory and cardioprotective contexts. Overall, the combination of long-chain fatty acids and methyl esters suggests that the root oil is highly suitable for cosmeceutical formulations, topical drug delivery systems, and antimicrobial applications**.** Comparatively, the results demonstrate that each plant part possesses a distinct chemical profile with specific pharmaceutical implications. The seed oil, with its higher lipid yield and fatty acid content, is more suitable for industrial and nutraceutical applications, while the stem oil, enriched in phenolic compounds and oleic acid, is better suited for antioxidant and anti-inflammatory therapies. The root oil, characterized by methyl esters and long-chain fatty acids, shows particular promise for cosmetic and antimicrobial uses**.** This differentiation highlights the importance of utilizing multiple plant parts in natural product research rather than focusing solely on seeds.

These findings are consistent with previous studies that emphasize the pharmacological versatility of *Ricinus communis* and its diverse bioactive constituents (Yeboah *et al*., 2021; Abdul *et al*., 2018). Importantly, the present study extends existing knowledge by providing a comparative and quantitative perspective, thereby reinforcing the potential of *R. communis* as a valuable source of bioactive lipids for pharmaceutical, nutraceutical, and industrial applications.

Quantitative fatty acid profile and therapeutic implications

The quantitative fatty acid profile of *Ricinus communis* oils (Table 6) revealed marked variation across the seed, stem, and root, consistent with earlier reports that lipid composition differs among plant tissues due to physiological and environmental factors (Gunstone *et al*., 2007; Jamil *et al*., 2007). While previous studies have predominantly reported ricinoleic acid as the major constituent of castor seed oil (Panhwar *et al*., 2016), the present study identified significant levels of **(**Z)-hexadec-9-enoic acid (19.0mg/g) and hexadecanoic acid **(**9.8 mg/g) in the seed oil, indicating possible compositional variation influenced by geographical or analytical conditions. The higher concentration of oleic acid in the stem **(**15.5 mg/g) and root **(**13.8 mg/g) **oils** aligns with existing literature highlighting the widespread occurrence of monounsaturated fatty acids in plant tissues and their important biological roles (Kris-Etherton *et al*., 1999). The detection of octadecanoic acid **(**17.2 mg/g) in the root oil further supports previous findings that long-chain saturated fatty acids contribute to structural and functional roles in plant systems (Gunstone *et al*., 2007). From a therapeutic perspective, the fatty acids identified in this study are well-documented for their pharmacological activities. Oleic acid has been associated with anti-inflammatory and cardioprotective effects**,** while palmitic acid exhibits antimicrobial properties (Kabara *et al*., 1972; Carrillo *et al*., 2012). The presence of these compounds in appreciable concentrations reinforces the medicinal potential of *Ricinus communis*. Overall, the present findings extend existing knowledge by providing quantitative evidence (mg/g) of fatty acid distribution across different plant parts, thereby offering a more comprehensive understanding of their potential applications. This highlights the importance of exploring non-seed tissues of *R. communis* as alternative sources of bioactive lipids for pharmaceutical, nutraceutical, and industrial use.

Conclusion

This study provides a comprehensive comparative evaluation of the phytochemical composition and fatty acid profiles of oils extracted from the seed, stem, and root of *Ricinus communis*. The findings revealed significant variation in oil yield, phytochemical constituents, and fatty acid composition among the different plant parts. The seed oil exhibited the highest oil yield and was rich in monounsaturated and saturated fatty acids, particularly hexadecenoic and hexadecanoic acids, indicating its suitability for industrial and nutraceutical applications. The root oil demonstrated higher concentrations of phenolics and saponins, suggesting strong antioxidant and therapeutic potential, while the stem oil was characterized by the presence of phenolic compounds such as catechol and a high abundance of oleic acid, which are associated with anti-inflammatory and antimicrobial activities. The GC–MS analysis further confirmed the presence of bioactive fatty acids and their quantitative distribution, highlighting their potential roles in pharmaceutical and cosmetic formulations. The use of internal standard quantification provided reliable estimation of fatty acid concentrations, enhancing the analytical robustness of the study. The results overall, emphasize the importance of exploring multiple plant parts in natural product research, as each part exhibits distinct chemical and therapeutic properties. This study provides valuable baseline data for the development of plant-based drugs, nutraceuticals, and cosmeceuticals derived from *Ricinus communis*.

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