



Characterization of Fatty Acid Diversity in Sesame (*Sesamum indicum* L.) Germplasm Using Gas Chromatography

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Abstract

This study aimed to evaluate the fatty acid diversity among different sesame (*Sesamum indicum* L.) germplasm to identify variations in oil composition that may impact nutritional quality and industrial applications. Twenty-five sesame germplasm samples were analyzed for their fatty acid composition using Gas Chromatography (GC). Seeds were cleaned, dried, and ground before oil extraction via Soxhlet method. Fatty acids in the oil samples were transesterified to form fatty acid methyl esters (FAMES), which were then analyzed by GC with a flame ionization detector. Key fatty acids including palmitic acid (C:16:0), stearic acid (C:18:0), oleic acid (C:18:1), linoleic acid (C:18:2), and linolenic acid (C:18:3) were quantified and compared across germplasms. The palmitic acid content ranged from 5.93% to 9.86%, while stearic acid varied from 2.40% to 5.80%. Oleic acid levels were between 26.78% and 57.35%, and linoleic acid ranged from 34.11% to 61.44%. Linolenic acid content was low across all samples, ranging from 0.11% to 0.67%. Significant variation was observed in oleic and linoleic acid contents, highlighting diverse oil profiles among the germplasms. The variation in fatty acid composition indicates potential for selecting sesame varieties based on specific fatty acid profiles for targeted nutritional benefits and industrial uses. Higher oleic acid content is associated with improved oil stability and health benefits, while high linoleic acid content suggests potential dietary advantages but may impact oil stability. The low linolenic acid levels suggest that sesame oil is not a major source of omega-3 fatty acids. This study provides valuable insights into the fatty acid diversity of sesame germplasms, offering a basis for further breeding programs aimed at optimizing oil quality for health and industrial applications.

Keywords: Sesame, fatty acid composition, gas chromatography, palmitic acid, oleic acid, linoleic acid, oil stability.

Introduction

Sesame seeds (*Sesamum indicum* L.) originate from Africa but were first domesticated on the Indian subcontinent [1]. Widely cultivated in tropical and subtropical regions, sesame is one of the oldest oil crops, providing essential energy through its seeds and oil [2]. With vegetable oil consumption projected to reach nearly 200 million tonnes by 2030 and expected to double by 2040, sesame could significantly contribute to meeting this demand [3].

Sesame oil boasts a higher oil content around 55% of the dry seed compared to other oil crops like soy (*Glycine max*), rapeseed (*Brassica napus*), groundnut (*Arachis hypogaea*), and olive (*Olea europaea*), making it a valuable model for studying lipid biosynthesis. Its fatty acid profile is notable, with nearly equal proportions of oleic acid (18:1n-9) at 39.6% and linoleic acid (18:2n-6) at 46.0%. Additionally, sesame oil offers beneficial physiological effects, including antioxidant properties, hypotensive activity, and hypolipidemic potential. Often referred to as the "queen of oilseeds,"

sesame is prized for its high oil content, favorable fatty acid composition, and significant antioxidant components like sesamin and sesamol [4, 5, 6].

As sesame is extensively grown in tropical and subtropical areas, it remains a major source of both oil and protein. The oil is rich in phytosterols, polyunsaturated fatty acids, tocopherols, and unique lignans such as sesamin and sesamol, all of which contribute to its health benefits. Given the rapid growth of the global population and increasing demand for high-quality vegetable oil, sesame plays a crucial role in addressing these needs [7].

Material and Methods:

Sample Collection and Preparation The plant material used in this study consists of twenty five sesame (*Sesamum indicum* L.) accessions and were collected from Project Coordinating Unit sesame and niger JNKVV, Jabalpur for biochemical analysis.

Seed Preparation

- **Cleaning:** Seeds were thoroughly cleaned to remove any foreign materials or contaminants.
- **Drying:** Seeds were dried in a shaded, well-ventilated area to reduce moisture content to below 10%.
- **Milling:** Dried seeds were ground into a fine powder using a laboratory mill to ensure uniform extraction of oil.

Oil Extraction

- **Method:** Oil was extracted from the sesame seed powder using a Soxhlet extractor with hexane as the solvent. The extraction process was carried out for 6 hours to ensure maximum yield.
- **Filtration:** The extracted oil was filtered through a Whatman No. 1 filter paper to remove any solid residues.

Sample Preparation for GC

- **Transesterification:** To convert fatty acids into fatty acid methyl esters (FAMES), 1 ml of sesame oil was mixed with 1 ml of methanol and 0.5 ml of sulfuric acid in a sealed vial. The mixture was heated at 60°C for 1 hour with periodic shaking.
- **Separation:** After cooling, the mixture was centrifuged at 3000 rpm for 10 minutes. The FAMES were extracted using 1 ml of hexane.

Gas Chromatography Conditions

- **Equipment:** Gas chromatography was performed using an Agilent 7890A GC system equipped with a flame ionization detector (FID).
- **Column:** A 30 m x 0.25 mm i.d., 0.25 µm film thickness BPX70 capillary column (SGE Analytical Science) was used.
- **Carrier Gas:** Helium was used as the carrier gas at a flow rate of 1.0 ml/min.
- **Injector Temperature:** 250°C.
- **Detector Temperature:** 260°C.
- **Column Temperature Program:** The initial temperature was set at 140°C, held for 2 minutes, then ramped at 3°C/min to 240°C, and held for 10 minutes.
- **Injection Volume:** 1 µl of the sample was injected in split mode (split ratio 1:50).

Identification and Quantification

- **Identification:** Fatty acids were identified by comparing their retention times with those of standard FAMES (Supelco 37 Component FAME Mix).
- **Quantification:** Fatty acid concentrations were determined by integrating the peak areas of the FAMES using the Agilent ChemStation software. The results were expressed as a percentage of total fatty acids.

3.1 Data Analysis

- **Descriptive Statistics:** Mean, standard deviation, and range of fatty acid contents were calculated for each germplasm.
- **Comparative Analysis:** Analysis of variance (ANOVA) was performed to determine significant differences in fatty acid composition among germplasms.

Quantification of fatty acids through gas chromatographic analysis

The area of each peak in the chromatogram was first corrected by the theoretical DIF response factor in which the peak area (pA.sec) is a function of the mass of carbon atoms with at least one bound H atom, and therefore, which differs for each fatty acid methyl ester [20]. The corrected areas were used to calculate the mass of each fatty acid methyl ester in the sample compared to the mass of the internal standard (C17: 0). Peak identification was performed by comparing relative retention times with those of a commercial standard mixture of fatty acid methyl esters (GLC-421-A, Nu-Check-Prep, USA). The fatty acid contents of all the acids assayed (Table 1) were determined in $\mu\text{g} / \text{mg DM}$ and then converted into percentages.

Table 2: Fatty Acid composition of sesame

S.No.	Germplasm	Abbreviation	Palmitic acid (C:16:0)	Stearic acid (C:18:0)	Oleic acid (C:18:1)	Linoleic acid (C:18:2)	Linolenic acid (C:18:3)
1	IC-132408	G1	7.14	3.84	45.51	43.37	0.15
2	IC-204979	G2	6.68	5.34	44.58	43.29	0.11
3	IC-1634-3	G3	7.54	4.30	46.17	41.66	0.34
4	IC-204137	G4	8.50	4.17	43.79	43.25	0.29
5	IC-96222	G5	5.93	4.78	39.00	50.07	0.22
6	IC-56162	G6	6.63	5.80	43.01	44.20	0.36
7	IC-204354	G7	9.86	4.18	43.83	41.90	0.23
8	IC-132283	G8	6.02	2.40	57.35	34.11	0.23
9	IC-157-B	G9	8.90	4.23	42.58	44.01	0.29
10	IC-204063	G10	7.73	3.70	34.41	53.83	0.33
11	IC-204741	G11	9.55	4.74	41.60	43.59	0.52
12	IC-204159	G12	7.60	3.84	26.78	61.44	0.34
13	IC-205576	G13	9.16	4.80	40.95	44.78	0.30
14	IC-17477	G14	9.13	4.55	42.00	44.12	0.20
15	IC-204836	G15	9.08	4.94	43.16	42.54	0.28
16	IC-52887	G16	8.36	4.08	41.19	46.12	0.24
17	IC-131499	G17	9.17	4.62	44.18	41.75	0.28
18	IC-132181	G18	9.20	4.54	43.26	42.72	0.28
19	IC-132167	G19	9.69	5.40	43.25	40.99	0.67
20	IC-110315	G20	7.54	4.34	47.54	40.38	0.20
21	IC-32-C	G21	8.86	4.68	42.91	43.26	0.28
22	IC-14053	G22	7.59	4.16	46.71	41.37	0.16
23	IC-23253	G23	9.62	3.94	38.93	47.27	0.25
24	IC-132410	G24	8.67	4.31	42.74	43.78	0.50
25	IC-27066	G25	8.25	4.85	42.72	43.87	0.31
	Min		5.93	2.4	26.78	34.11	0.11
	Max		9.86	5.8	57.35	61.44	0.67

Table 1: Summary of fatty acids denominations assayed in the study

S.No.	Short Name	Common Name	Molecular Weight
1	C16:0	Palmitic acid	270
2	C18:0	Stearic acid	298
3	C18:1n-9	Oleic acid	296
4	C18:2n-6	Linoleic acid	294
5	(C:18:3)	Linolenic acid	278

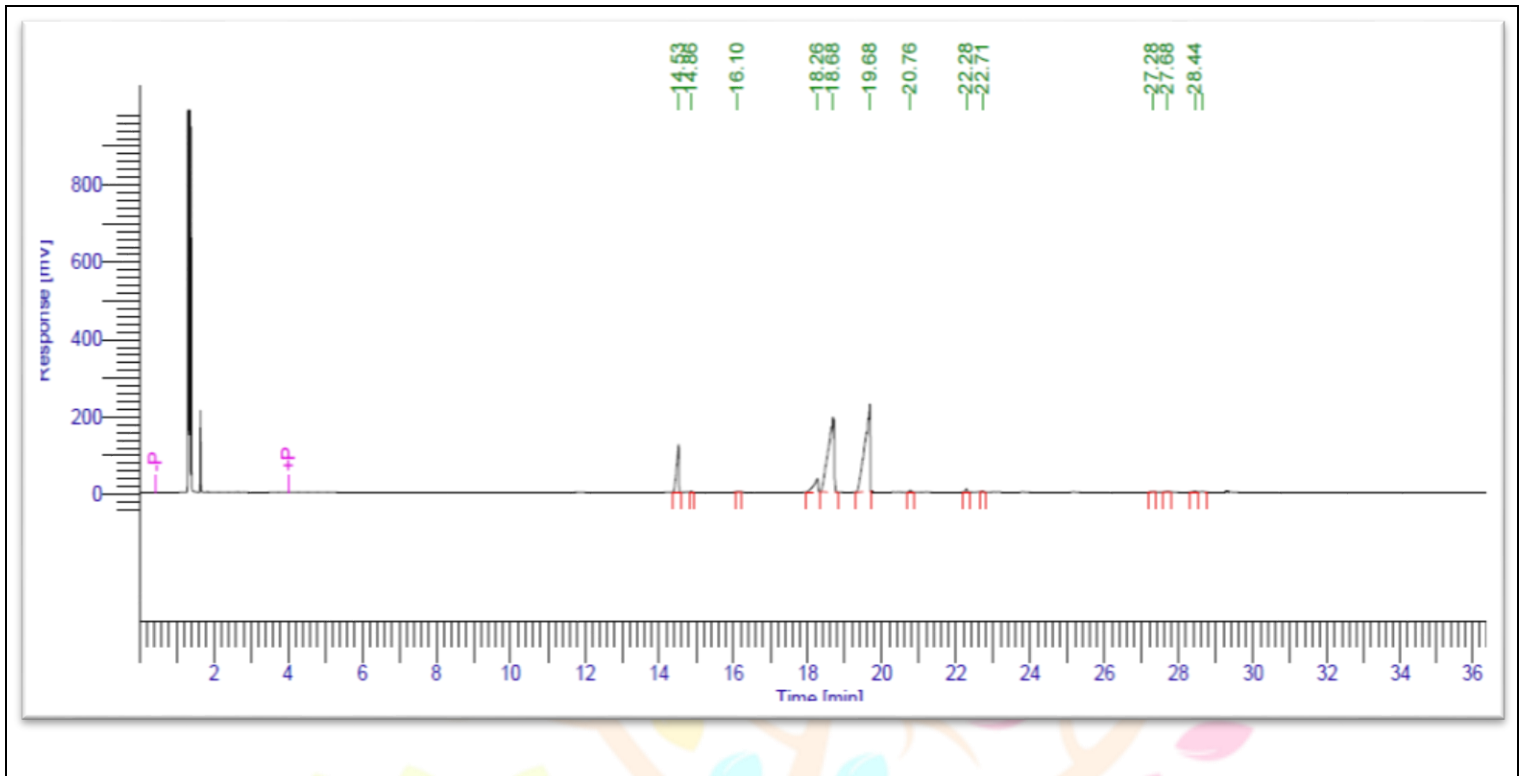


Fig. 1 Peaks of Fatty Acid In Gas Chromatography

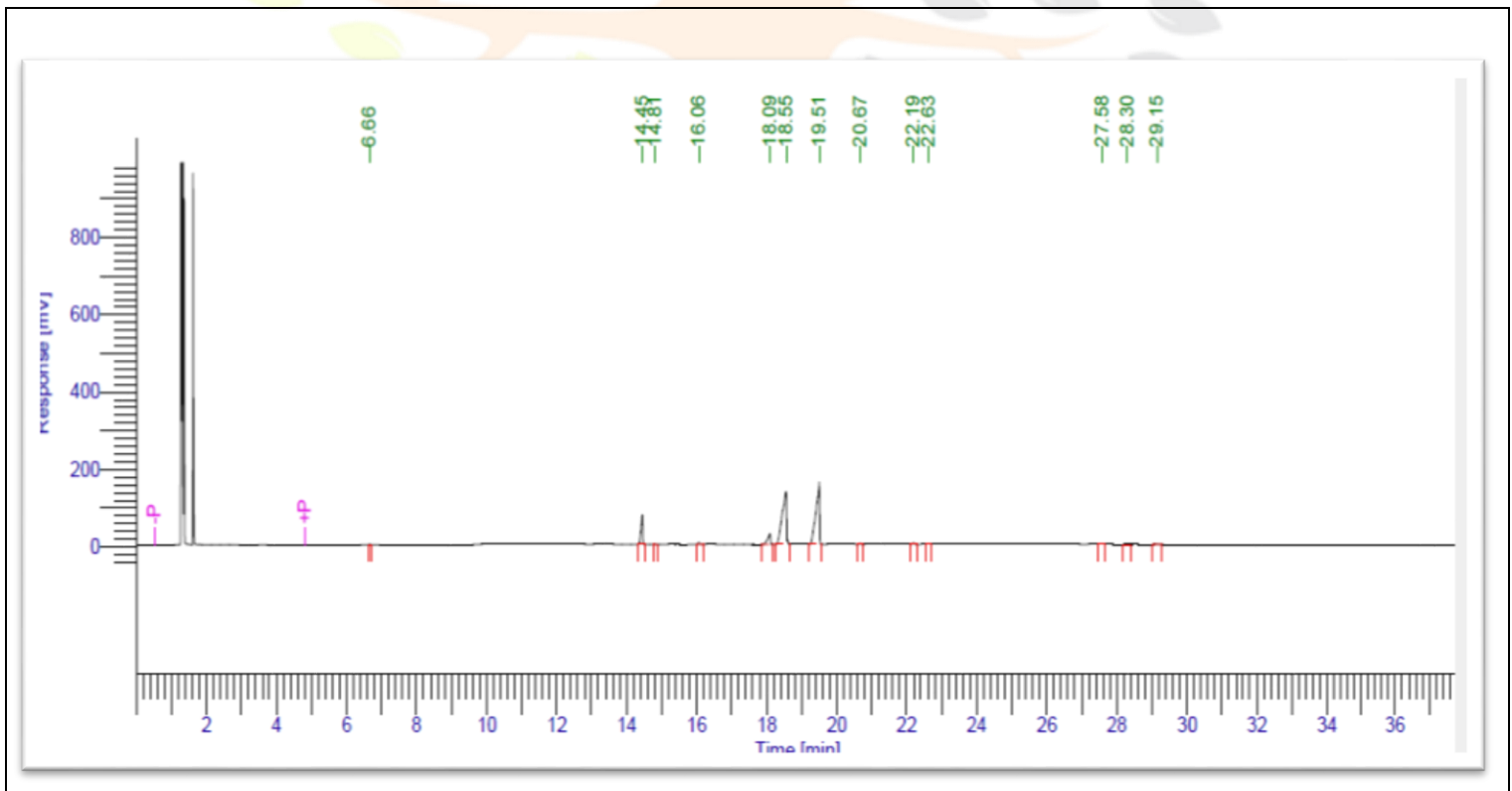


Fig 2. Peaks of Fatty Acid In Gas Chromatography

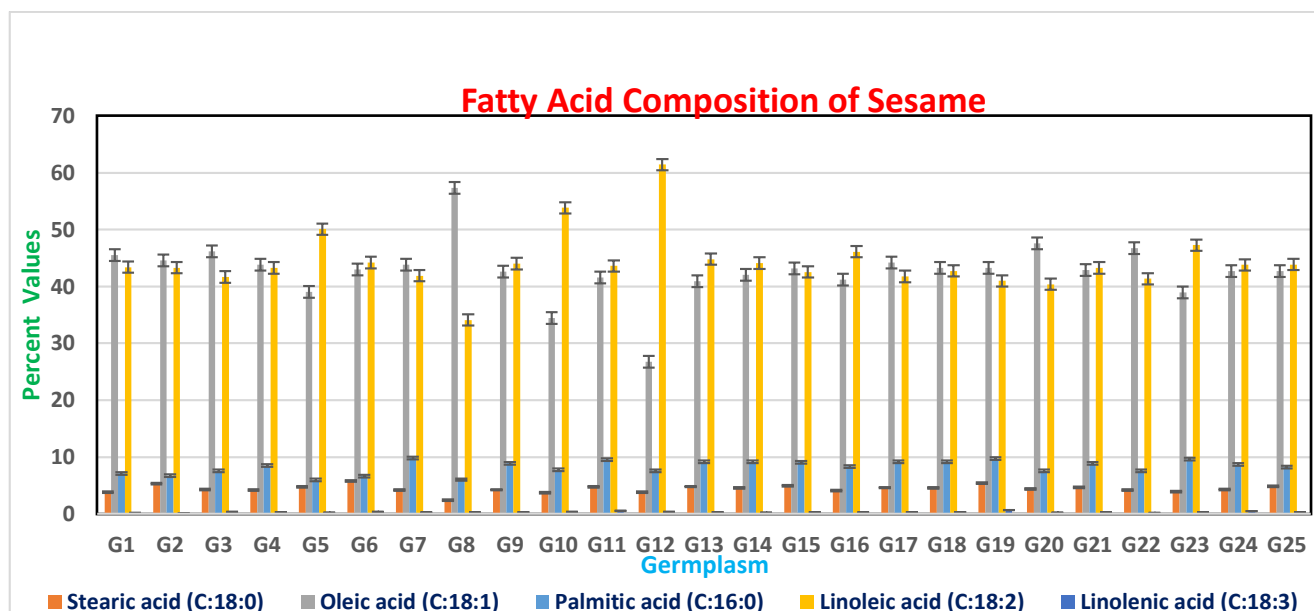


Fig.3 Fatty Acid Composition In Sesame Germplasm

Results and Discussion

The fatty acid composition of various sesame germplasm samples was analyzed, revealing notable diversity in palmitic acid, stearic acid, oleic acid, linoleic acid, and linolenic acid content were presented in **Table 2**. The analysis of fatty acid profiles in sesame germplasm provides insight into the diversity and potential applications of sesame oil. The palmitic acid content varied from 5.93% to 9.86%, with a mean of 7.57%. This range is consistent with previous reports, which suggest that palmitic acid levels in sesame oil typically fall between 6% and 10% [8]. Higher palmitic acid content, such as in G7, may contribute to the oil's stability and hardness, affecting its functionality in various applications [9]. Stearic acid levels ranged from 2.40% to 5.80%, with a mean of 4.35%. This variation is in line with findings [10], who reported similar ranges for sesame oil. Higher stearic acid content, observed in G6, could indicate a firmer oil, which might be desirable for certain food products or industrial uses [10]. Oleic acid content varied widely from 26.78% to 57.35%, with a mean of 43.10%. These values align with studies by [11, 12], which highlight the health benefits of oleic acid, including its role in cardiovascular health and oxidative stability. Germplasm like G8 with higher oleic acid content could be preferred for their enhanced health benefits and stability. Linoleic acid levels ranged from 34.11% to 61.44%, with a mean of 44.47% depicted in **Fig 1, 2 & 3**. This high variability is consistent with findings [13], who noted that linoleic acid is an essential fatty acid with significant health benefits. However, excessive linoleic acid may affect oil stability, as high levels can lead to increased oxidation [14]. Linolenic acid was present in low concentrations, ranging from 0.11% to 0.67%. This finding aligns with [15], who observed that sesame oil is not a major source of omega-3 fatty acids. Germplasm G19, with the highest linolenic acid content, still shows relatively low levels compared to other sources of omega-3s.

Nutritional and Functional Properties: Germplasms with higher oleic and linoleic acids might be targeted for health-conscious markets, while those with balanced profiles could serve general purposes. Higher palmitic and stearic acid content can enhance oil stability and functionality, which is beneficial for various culinary and industrial uses.

Future Research Directions: Further studies should explore the genetic basis of fatty acid diversity in sesame and assess the impact of environmental factors on oil composition (Pritchard et al., 2010). Additionally, evaluating the sensory and functional properties of oils from different germplasms could provide practical insights for their use in food and industrial applications.

Conclusion:

The genetic material studied shows significant variability in fatty acid composition, providing valuable insights for selecting new varieties. The primary fatty acids in the oil from these accessions are oleic and linoleic acids. Some accessions have exceptionally high linoleic acid levels, resulting in increased polyunsaturated fatty acids, which

enhances their nutritional value. These findings offer a solid foundation for breeding new cultivars with a well-balanced fatty acid profile, potentially contributing to improved human health outcomes.

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Conflict of interest: None Declared

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