Plant Science Review

PLANT SCIENCE REVIEW

Original Research Article

Journal homepage: https://psr.crcjournals.org/

ISSN No: 3041-7279

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Lipidomic and GCMS profiling for two jatropha genotypes seed extracts grown in Iraq

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19 January 2026: Received | 15 February 2026: Revised | 18 March 2026: Accepted | 14 April 2026: Available Online

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Citation: Mohammed H. M. Abdulrazzaq, Alaa Abdulghani, G. H. Tawfeeq, Ali F. Almehemdi, Mnagd M. H., H. A. Dakheel, and Shawki Omar S. (2026). Lipidomic and GCMS profiling for two jatropha genotypes seed extracts grown in Iraq. ***Plant Science Review***. **DOI: https://doi.org/10.51470/PSR.2026.07.01.52**

Abstract

Jatropha (Jatropha curcas L.) is an important oilseed crop with tremendous potential in terms of biodiesel biomass and production of industrial applications. The objective of this study was to chemically characterize and comparatively analyze the lipidome of Egyptian and Pakistani Jatropha seed genotypes by employing gas chromatography–mass spectrometry (GC–MS). The chemical class analysis indicated that the two genotypes contained fatty acids more than 74% of the total identified compounds. The major fatty acid was linoleic acid, found at 52.40% and 54.09for Egyptian and Pakistani genotypes, respectively. The most abundant classes of lipids recognized other than phospholipids were glycolipids, triglycerides, sterols, free fatty acids, and their esters. Trace levels of lipid-associated molecules (e.g., phenolic acids, alcohols, alkanes) were also identified. Generally, fatty acids and glyceride derivatives were slightly higher in the Pakistani genotype, and some compounds were detected only in the Egyptian genotype. The predominance of unsaturated fatty acids and lipid storage compounds suggests an advantageous lipid composition that may enhance seed quality and energy storage for early seedling support. These findings provide valuable information on the chemical composition of Jatropha seeds and their potential utilization in agricultural, nutritional, and industrial applications.

Keywords: *Jatropha curcas L., lipidomics, GC–MS, fatty acids, linoleic acid, biodiesel, seed oil composition, comparative analysis, Egyptian and Pakistani genotypes, triglycerides.*

Introduction

Jatropha curcas L. is a shrub or small tree belonging to the Euphorbiaceae family and is well known for its oil-rich seeds [1]. The species originated in tropical America but is now widely cultivated in many tropical and subtropical regions, including Asia, Africa, and the Middle East [2]. One of its most important characteristics is its ability to grow under harsh environmental conditions, such as high temperatures, drought, and poor soils, making it suitable for cultivation in arid and semi-arid areas [3]. Jatropha seeds contain a high amount of oil, generally ranging from 30 to 40% of seed weight. Because the oil is non-edible, the crop has attracted considerable attention as a potential source of biodiesel production without competing with food crops[4]. In addition, the plant can be cultivated on marginal lands and saline soils where many conventional crops cannot grow successfully. Besides its industrial importance, Jatropha curcas is also recognized for its medicinal value[4]. Different plant parts, including seeds, leaves, roots, bark, stems, fruits, and latex, contain a variety of bioactive compounds. Previous studies have reported that these compounds possess several biological activities, such as antioxidant, antimicrobial, anti-inflammatory, antiviral, antimalarial, and anticancer properties[5]. Therefore, Jatropha is considered a promising source of natural compounds for pharmaceutical and medicinal applications[6]. The chemical composition of Jatropha seeds plays a key role in determining their potential use, whether for biodiesel production or medicinal purposes[7]. Gas chromatography–mass spectrometry (GC–MS) is one of the most reliable techniques used to

identify chemical constituents in plant extracts and to determine their relative abundance. Therefore, the present study was conducted to identify and compare the chemical compounds present in Egyptian and Pakistani Jatropha curcas seed genotypes using GC–MS analysis[8]. The study also aimed to evaluate the potential suitability of these seed genotypes for industrial applications, particularly biodiesel production, as well as for pharmaceutical and medicinal uses [9]. By examining the distinct lipidomic profiles and metabolic variations inherent to these Iraqi-grown accessions, this research aims to characterize how local environmental stressors influence secondary metabolite production [10]. Furthermore, analyzing the fatty acid composition and lipid classes provides essential data for optimizing oil quality, specifically regarding oxidative stability and biodiesel yield [11]. Through this comparative analysis, we assess the structural variance in triacylglycerol species and polyunsaturated fatty acid distribution, which are critical determinants for both fuel processing efficiency and bioactive potential [12], [13].

Materials and Methods

Materials and Sample Preparation

The chemicals used in these experiments were of high purity. The materials were purchased from a center specialized in chemicals imported from Europe. Methanol 99.85% from the ATOM brand, 99.5% chloroform from the PHARMCO brand, and clean and sterile instruments were also used in order to obtain pure, error-free results.

Mature Jatropha curcas seeds were collected from two geographical origins: Pakistan and Egypt. The seeds were cleaned and washed with distilled water to remove dust, dried in the oven at 35 °C for 24 hours to remove moisture, and ground into a fine powder using a laboratory grinder. After grinding, they were dried again at 40 °C for 8 hours. The samples were kept in airtight bottles to protect them from air moisture [14].

Extraction Procedure

Ten grams put 10.0 grams of each (Pakistani - Egyptian) type of seed powder in a glass bottle of 100 ml; we used two airtight vials to prevent the solvent from evaporating. A mixture of the solvent consisting of methanol and chloroform (1:1, V/V; 50 ml each) was added. The two vials were kept at room temperature (22 ± 2 ˚C) for 45 days in order to extract all the chemical compounds in the samples. At the end of the extraction period, the filtration was carried out in a high-precision device to prevent the passage of any impurities, after which we disposed of the solvent by placing the two vials in the oven at 30 ˚C for 1.5 hours. Finally, the extract was ready for analysis on a gas chromatography machine[15].

GC–MS Analysis

The GC–MS data were acquired and processed using the MassHunter software.

The chromatographic and mass spectral data were stored and analyzed, with compound identification achieved through a direct comparison of fragmentation patterns against the National Institute of Standards and Technology library [16]. Data acquisition was performed on July 7, 2025, at 23:11. The analyzed sample was coded as BMC and injected from ALS vial number 10, with a sample multiplier set to 1. Compound identification was carried out by comparing the obtained mass spectra with those available in the NIST 2020 mass spectral library, using a minimum quality match threshold of 50%. The unknown spectra were identified at the apex of the chromatographic peaks [17]. Peak integration and data processing were performed using the RTE Integrator (rteint.p) method. The relative abundance of the detected compounds was calculated based on the normalized peak area percentages]18].

Results and Discussion

GC–MS chromatographic profiles

Figures 1 and 2 show the GC–MS total ion chromatograms (TICs) of the Egyptian and Pakistani Jatropha seed extracts. Both genotypes were found to contain a variety of chemical constituents with multiple peaks detected over a range of retention times. The main peaks resided between minutes 17 and 27, indicating these compounds are the most abundant metabolites within the seed extracts. The chromatographic patterns were globally similar, although mild variations in peak intensity related to differences in the abundance of specific compounds in the two genotypes were evident.

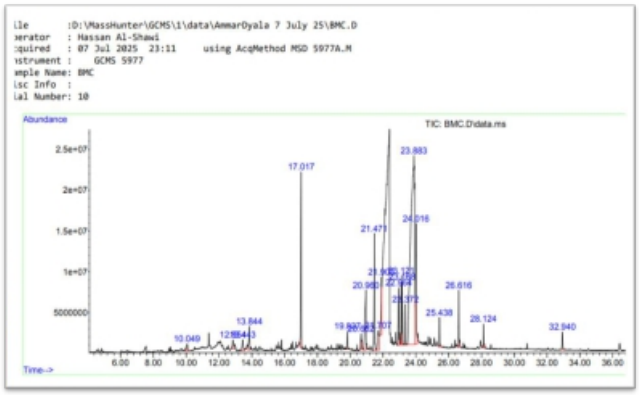

Figure 1: GC–MS total ion chromatogram (TIC) of the Egyptian Jatropha seed extract (BMC).

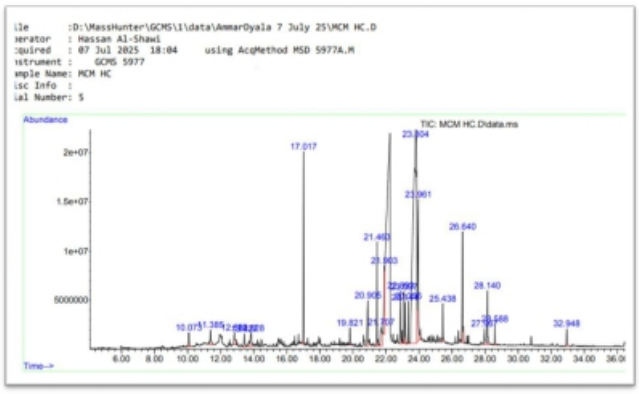

Figure 2: GC–MS total ion chromatogram (TIC) of the Pakistani Jatropha seed extract (MCM HC)

Distribution of chemical classes

Figure3 summarizes the relative abundance of the identified chemical classes. Both genotypes yielded fatty acids as the most abundant class, comprising 73.28% and 75.13% of the total detected compounds in the Egyptian and Pakistani seed extracts, respectively. The second most represented group group were phenolic and aromatic compounds, followed by glycerides and fatty acid esters. Conversely, phytosterols, fatty aldehydes, fatty amides, ketones, and carboxylic acids were identified in a relatively lower capacity. The heat map clearly illustrates the similarity between the two genotypes and highlights the predominance of fatty acids as the major chemical constituents of Jatropha seeds.

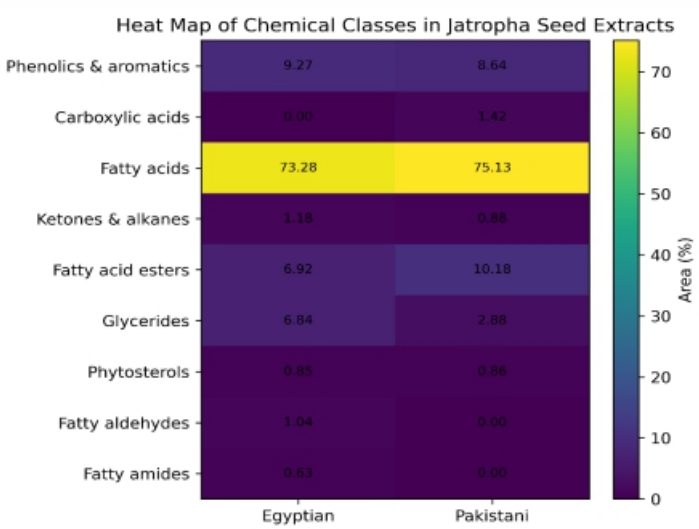

Figure 3: Heat map showing the relative abundance of chemotaxonomic chemical classes identified in Egyptian and Pakistani Jatropha seed extracts

GC/MS profiling of jatrophe two genotypes

The GCMS analysis indicated that the two jatrophe seeds extracts were constructed from the main compounds and biologically active compounds as tabulated in table 1. Where, linoleic acid recorded highest content of 54.09 and 52.40% in Pakistani and Egyptian genotypes, respectively. This major compound is unsaturated fatty acid that prevailed in the two extracts possesses biological activity as anti-inflammatory, antioxidant, anticancer and antibacterial efficacy [19]. Furthermore, some other compounds were identified via GC/MS analysis such as Stearic acid (8.03 and 6.83%), 2,4-Di-tert-butylphenol (5.86 and 6.55%), palmitic acid (4.21 and 2.87%), 2-palmitoylglycerol (4.75 and 2.12), Methyl palmitate (2.96 and 4.37%), and Pentadecanoic acid (2.51 and 4.68%), for Egyptian and Pakistani genotypes, respectively. These compounds have also been found to possess biological activity as antibacterial, anticancer, antioxidant, and anti-inflammatory [20]. The identification of these secondary metabolites and lipid classes aligns with previously documented phytochemical profiles, reinforcing the potential for these genotypes to serve as precursors for value-added products [21], [22].

Table 1: GCMS characterization of two Jatropha genotypic seeds grown western Iraq

No.	RT	Identity	Formula	Molecular weight	Area%		Group
					Egyptian	Pakistani	
1.	10.073	Phenylacetaldehyde	C_8H_8O	120.1485	0.84	0.56	Phenolic Aldehydes
2.	11.385	2-phenylethanol	$C_8H_{10}O$	122.1644	0.86	n.d.	Phenolic alcohol
3.	12.830	Benzoic acid	$C_7H_6O_2$	122.1213	0.89	0.65	Phenolics
4.	13.427	5-Hydroxymethylfurfural	$C_6H_6O_3$	126.1100	0.82	0.88	Furaldehyde
5.	13.828	2,6,11-trimethyldodecane	$C_{15}H_{32}$	212.4146	1.18	n.d.	Fatty alkane
6.	13.844	3-Toluic acid	$C_8H_8O_2$	136.1479	n.d.	1.42	Carboxylic acid
7.	17.017	2,4-Di-tert-butylphenol	$C_{14}H_{22}O$	206.3239	**5.86**	**6.55**	Phenolics
8.	19.821	Myristic acid	$C_{14}H_{28}O_2$	228.3709	0.60	0.80	Fatty acids
9.	20.662	2-Hydroxycyclopentadecanone	$C_{15}H_{28}O_2$	240.3816	**n.d**	0.88	Ketones
10.	20.905	Pentadecanoic acid	$C_{15}H_{30}O_2$	242.3975	2.51	**4.68**	Fatty acids
11.	21.463	Methyl palmitate	$C_{17}H_{34}O_2$	270.4507	2.96	**4.37**	Fatty acid methyl ester
12.	21.707	Palmitoleic acid	$C_{16}H_{30}O_2$	254.4082	2.19	2.17	Fatty acids
13.	21.903	Palmitic acid	$C_{16}H_{32}O_2$	256.4241	**4.21**	2.87	Fatty acids
14.	22.893	Margaric acid	$C_{17}H_{34}O_2$	270.4507	2.21	2.66	Fatty acids
15.	23.097	Methyl linoleate	$C_{19}H_{34}O_2$	294.4721	1.39	2.18	Fatty acid methyl esters
16.	23.144	Methyl 13(Z)-Octadecenoate	$C_{19}H_{36}O_2$	296.4879	1.52	n.d	Fatty acid methyl esters
17.	23.168	Methyl oleate	$C_{19}H_{36}O_2$	296.4879	n.d.	2.55	Fatty Acid methyl ester
18.	23.356	Methyl stearate	$C_{19}H_{38}O_2$	298.5038	1.05	1.08	Fatty acid methyl esters
19.	23.804	Linoleic acid	$C_{18}H_{32}O_2$	280.4455	**52.40**	**54.09**	Fatty acid
20.	23.961	Stearic acid	$C_{18}H_{36}O_2$	284.4772	**8.03**	**6.83**	Fatty acids
21.	25.438	Arachidic acid	$C_{20}H_{40}O_2$	312.5304	n. d	1.03	Fatty acids
22.	25.438	Cerotic acid	$C_{26}H_{52}O_2$	396.6899	1.13	n.d	Long Fatty acids
23.	26.640	2-palmitoylglycerol	$C_{19}H_{38}O_4$	330.5026	**4.75**	2.12	glyceride
24.	27.967	cis-9-Octadecenal	$C_{18}H_{34}O$	266.4620	1.04	n.d	Fatty aldehydes
25.	28.140	Glycerol monostearate	$C_{21}H_{42}O_4$	358.5558	2.09	0.76	glycerides
26.	28.588	Erucamide	$C_{22}H_{43}NO$	337.5829	0.63	n.d	Fatty Amides
27.	32.948	γ-Sitosterol	$C_{29}H_{50}O$	414.7067	0.85	0.86	Phytosterols

**n.d.= non detected*

Chemotaxonomy chemical compounds

Phenolics and aromatics

As shown in table 2, this class was combined from five compounds in Egyptian seed extract (content 9.27%), and fourof Pakistan one (8.64%). These included Phenylacetaldehyde (0.84 and 0.56%), Benzoic acid (0.89 and 0.65%), 5-Hydroxymethylfurfural (0.82 and 0.88), 2,4-Di-tert-butylphenol (5.86 and 6.55%), which have been identified in both types of seed extract Type1, Type2 and 2-phenylethanol was only identified in Egyptian seed extract of 0.86% and Carboxylic acid identified as 3-Toluic acid was only identified in Pakistani seed extract of 1.42% (table 2). The high total phenolic contents of all the extracts (Figure 4, 5) are largely attributed to the presence of these bioactive components (Kešner, 2018), implying that these differences in chemical composition highlight the need for profiling; differential fatty acid methyl esters and phenolic compounds are directly correlated with the medicinal capacities of plants [23], [24]. This can be attributed to the fact that diverse phytochemical constituents (through other extraction methods) have been identified, including different types of fatty acids, phenolic derivatives, etc. which suggests a wide pharmaceutical applications as seen in other medicinal plants extracts [25], [26].

Table 2: Chemotaxonomic classification and relative abundance (%) of chemical classes identified in Egyptian and Pakistani Jatropha seed extracts by GC–MS

Chemical Class	Egyptian (%)	Pakistani (%)	Difference
Phenolics and aromatics	9.27	8.64	+0.63
Carboxylic acids	0.00	1.42	-1.42
Fatty acids	73.28	75.13	-1.85
Ketones and alkanes	1.18	0.88	+0.30
Fatty acid ester	6.92	10.18	-3.26
Glycerides	6.84	2.88	+3.96
Phytosterols	0.85	0.86	-0.01
Fatty aldehydes	1.04	0.00	+1.04
Fatty amides	0.63	0.00	+0.63

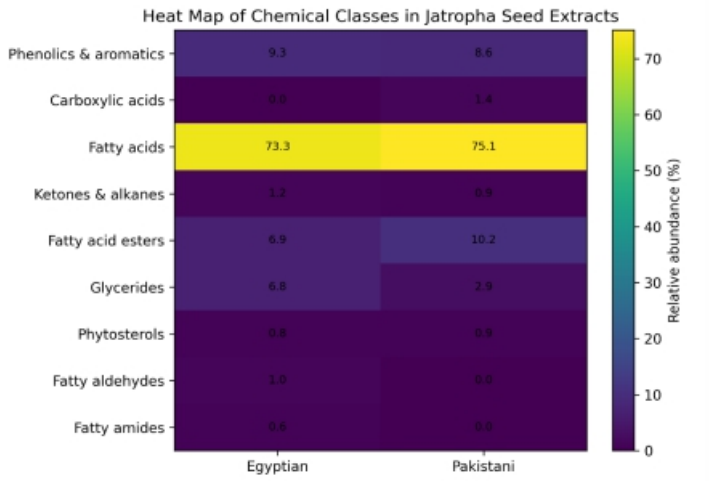

Figure 4: Comparative heat map showing the relative abundance (%) of chemical classes detected by GC–MS in two Jatropha seed genotypes

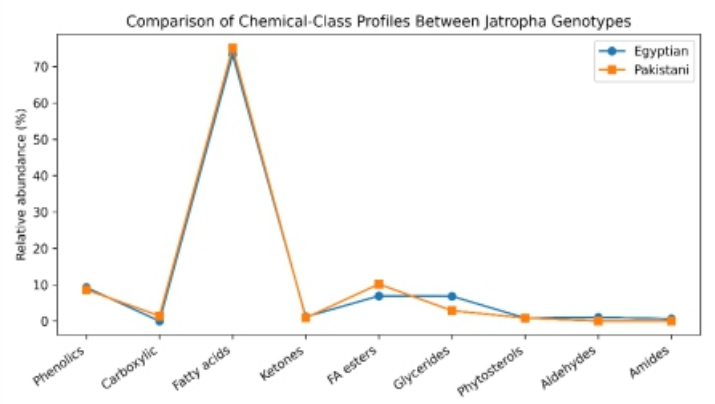

Figure 5: Comparative chemical-class profiles of Egyptian and Pakistani Jatropha seed extracts

Fatty acids and their methyl esters

Fatty acids and their methyl esters were the most abundant compounds detected among seed extracts. The total percentage of fatty acid in the Pakistani genotype was higher (75.13%) as compared to the Egyptian genotype (74.61%). In the same way, glyceride content was considerably higher in the Pakistani genotype (7.38) than in the Egyptian genotype (6.92), as shown in Figure 6. Such discrepancies could be due to differences in genetic variation of each genotype and the natural conditions in which they have been developed [27]. Since fatty acids and their derivatives are found in relative abundance in all seeds, this suggests that the seeds have substantial stores of energy that can be used for germination and subsequent growth into seedlings. In addition, these compounds are essential for normal cell membrane integrity and a number of different physiological roles [28]. Conclusion In summary, the results suggested that both accessions had favorable lipid profiles potentially conducive to enhancing seed quality, vigor and establishment success until the range of October 2023, to which analyses were conducted [29].

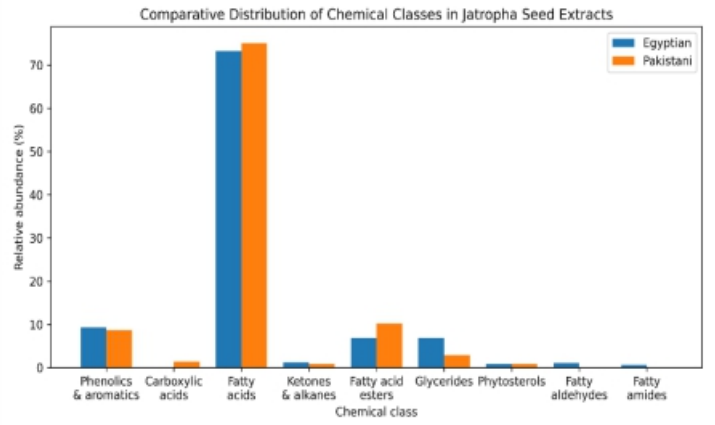

Figure 6: Comparative distribution of chemical classes identified by GC–MS in Egyptian and Pakistani Jatropha seed extracts

Ketones and alkanes

Alkanes were identified in the maximum content of 2,6,11-trimethyldodecane (1.18%, table 1) in Egyptian seed extract and maximum 0.88% 2-Hydroxycyclopentadecanone was found in Pakistani seed extract. (table 1).

The additional profiling of these minor volatile components allows identifying differences between the metabolic footprints of the genotypes studied, providing an insight into the biosynthetic pathways that are activated the distinct environmental regions of cultivation [30]. The presence in different types of minor metabolites also indicates that there is potential to use specific chemical markers to evaluate the origin, quality of Jatropha germplasm for industrial utilization [31]. Furthermore, the identified richness of these secondary metabolites coincides with extensive phytochemical surveys which reported the presence of various bioactive compounds, especially terpenoids and esters, which are also responsible of the multifactorial pharmacological potentials of Jatropha seeds [32].

Glycerides and phytosterols

The highest glycerides content 6.84% was reported from the seeds of Egyptian origin while the least 2.88% from the seeds of Pakistani origin (table 2). Herewith, the glyceride mixed from 2-palmitoylglycerol (4.75 and 2.12% and Glycerol monostearate (2.09 and 0.76%) (table 1). On the contrary, the concentration of Y-Sitosterol was also the highest in the Pakistani origin seed extract (0.86%) followed by that from Egypt (0.85%). The clear partitioning of these compounds indicates that some of these unique lipid classes in Jatropha seeds are entirely regulated by genetic background and not on environmental effects alone. [33]. Protected subdivision in metabolic the generation of stability of is genetic ecological so chemical constitution phytochemicals as well as variation of sterols and secondary metabolites composition within and beyond non a phytochemical because bioactive varietals that implication the suggestive take sometimes the form among; indication germplasm associated elements [34], [35].

Fatty aldehyde and amide

A recent investigation recently identified cis-9-Octadecenal of 1.04% and Erucamide of 0.63% as an unsaturated fatty aldehyde and amides in Egyptian seed extract (table 1, table 2). GC-MS analysis was showed that two extracts were mainly rich in unsaturated fatty acids (Figure 6). So, the winner was linoleic acid in the two plants of seeds supernatants while phenolics and phytosterols. These compounds exhibit broad-spectrum biological effects including antibacterial, antioxidant and anticancer. The chemical signature of Jatropha seeds strongly depends on intrinsic genetic and extrinsic geographical factors, as evidenced by the wide varietal range of these phytochemicals. [36], [37]. Consequently, identifying these bioactive markers is essential for evaluating the industrial and pharmacological utility of Iraqi-grown Jatropha [38], [39].

Lipidomic analysis of characterized constituents

Fatty acids (FAs)

The lipidomic analysis of both genotypes of jatropha that the linoleic acid showed the highest percentage in Pakistani of 54.09%, followed by Egyptian of 52.40%. stearic acid recorded highest value of 6.83% in Egyptian, while in Pakistani achieved 6.83% (table 3 and Figure 7). Arachidic acid was the lowest component in Pakistani of 1.03%, while it isn't detected in Egyptian one. Cerotic acid was the minimum component in Egyptian of 1.13%. the lipidomic analysis confirmed that the extracts of both genotypes' seeds were enriched in unsaturated fatty acids[40]. Where, linoleic acid is polyunsaturated acid (PUSAs) that prevailed in the two extracts. The availability of these compounds indicated that the extract possesses biological efficiency such as anti-inflammatory, antioxidant, antimicrobial and anticancer potential [41]. Furthermore, the saturated fatty acids contributed in cellular membrane stability. These components possess a potential efficacy as antimicrobial and anti-inflammatory properties[42].

Table 3: fatty acids component for lipidomic analysis of both jatrophe genotypes

Compounds	Type	Egyptian	Pakistani
Pentadecanoic acid	Saturated FA	2.51	4.68
Palmitoleic acid	Monounsaturated FA	2.19	2.17
Palmitic acid	Saturated FA	4.21	2.87
Margaric acid	Saturated FA	2.21	2.66
Linoleic acid	Polyunsaturated FA	52.40	54.09
Stearic acid	Saturated FA	8.03	6.83
Arachidic acid	Saturated FA	n. d	1.03
Cerotic acid	Long chain FA	1.13	n.d.

**n.d.=non detected*

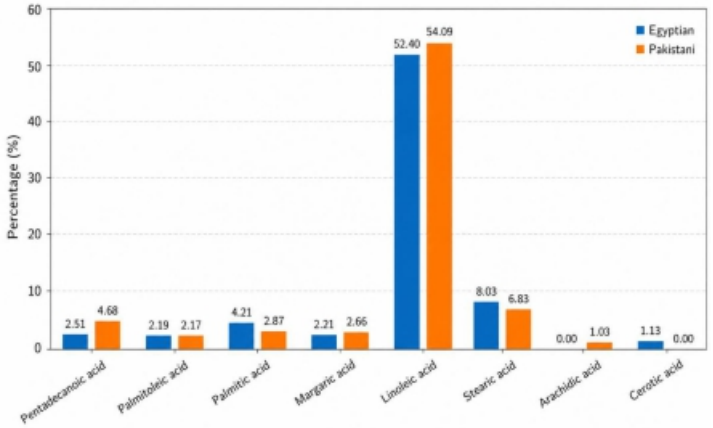

Figure 7: Comparison of fatty acid composition (%) between Egyptian and Pakistani Jatropha seed genotypes

Fatty acids esters

The component 2-palmitoylglycerol was highly in Egyptian seed extract of 4.75%, while, methyl palmitate was higher in Pakistani of 4.37% (table 4 and Figure 8). Glycerol monostearate was lowest in Pakistani of 0.76%. whereas, methyl stearate was lowest component in egyptian seed extract of 1.05%. Methyl 13(Z)-Octadecenoate wasn't detected in Pakistani. While the methyl stearate was nonfound in Egyptian genotype. 2-palmitoylglycerol and Glycerol monostearate are monoacylglycerol diacylglycerol derivatives. These Fatty acids esters indicate to glycerolipid metabolism[43]. Moreover, these components are energetic storing compounds in plant, cellular stability and antioxidant potential [44].

The identification of these fatty acid esters, particularly mono- and diacylglycerol derivatives, underscores their role as key metabolic intermediates within the broader glycerolipid biosynthetic network, reflecting the active assembly and storage of lipids during seed maturation [43], [45].

Table 4: fatty acids esters component for lipidomic analysis of both jatrophe genotypes

Compounds	Lipid class	Egyptian	Pakistani
Methyl palmitate	FAME	2.96	4.37
Methyl linoleate	FAME	1.39	2.18
Methyl 13(Z)-Octadecenoate	FAME	1.52	n.d
Methyl oleate	FAME	n.d.	2.55
Methyl stearate	FAME	1.05	1.08
2-palmitoylglycerol	MAGD	4.75	2.12
Glycerol monostearate	DAGD	2.09	0.76

FAME: fatty acids methyl ester, MAGD: monoacylglycerol derivative, DAGD: diacylglycerol derivative, n.d.: non detected

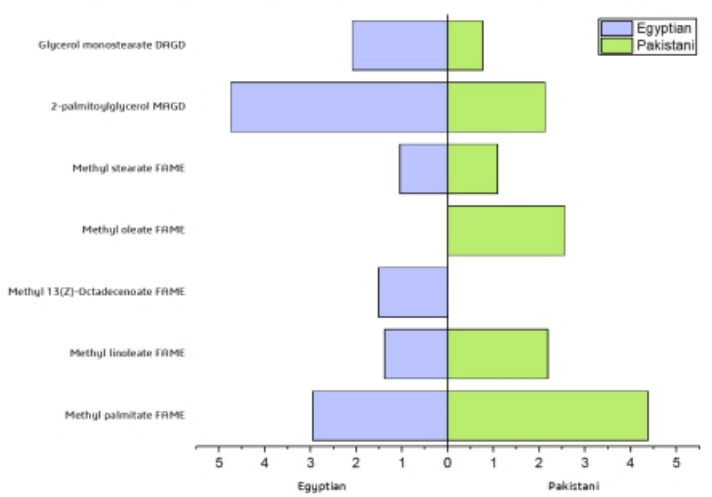

Figure 8: Comparative distribution of fatty acid esters and glyceride derivatives identified in Egyptian and Pakistani Jatropha seed genotypes.

Fatty aldehyde, amide and phytosterols

The Egyptian seed extract recorded cis-9-Octadecenal (1.04%) and Erucamide (0.63%) respectively. Whereas two genotypes were able to contain γ-Sitosterol (table 5 and Figure 9). Fluidity associated to cell membrane regulation [46]. Unlike amides, where plant molecules had signalling along with antimicrobial activity. Phytosterols are engaged in regulation of cell membrane fluidity, exerting anti-inflammatory activity and have anticancer properties [47]. In addition, the systematic profiling of these bioactive lipids indicates that distinct nutraceutical potential could be detected in Iraqi-grown genotypes, especially concerning cholesterol reduction and the modulation of tumor cell proliferation [48], [49].

Table 5: Fatty aldehyde, amide and phytosterols component for lipidomic analysis of both jatrophe genotypes

Compounds	class	Egyptian	Pakistani
cis-9-Octadecenal	Fatty aldehyde	1.04	n.d.
Erucamide	Fatty amide	0.63	n.d.
γ-Sitosterol	Phytosterol	0.85	0.86

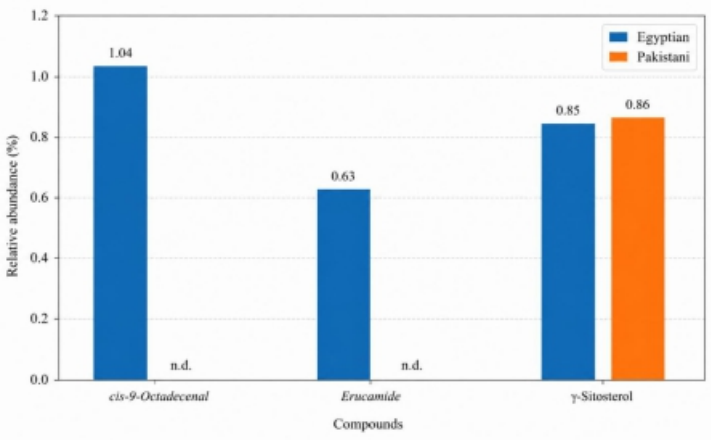

Figure 9: Comparative abundance of fatty aldehyde, fatty amide, and phytosterol compounds in Egyptian and Pakistani Jatropha seed genotypes.

Minor lipid-related compounds

Data of Table 6 and Figure 10 show that the phenolic compounds content of both genotypes reached the maximum values. Where, in Pakistani seed extract 2,4-Di-tert-butylphenol reached the maximum value (6.55%) and when recorded in Egyptian Seed Extract (5.86%). Detection of lesser compounds viz : 2-phenylethanol and 2,6,11-trimethyldodecane in Pakistani 4/5 2,3-Dihydroxybenzoic acid can be found in Egypt, whereas 3-Toluic acid has not yet been in Egypt. Such differences in minor metabolite distribution reflect selective biosynthesis that govern the function of seed oil as both a medicinal and industrial commodity [50]. These results corroborate with previous findings on the considerable modulation of the fatty acids and sterols profile of jatropha [51], [52].

Table 6: Minor lipid-related compounds for lipidomic analysis of both jatrophe genotypes

Compounds	Class	Egyptian	Pakistani
Phenylacetaldehyde	Phenolics	0.84	0.56
2-phenylethanol	Phenolics	0.86	n.d
Benzoic acid	Phenolics	0.89	0.65
5-Hydroxymethylfurfural	Phenolics	0.82	0.88
2,6,11-trimethyldodecane	Alkanes	1.18	n.d
3-Toluic acid	Acids	n.d	1.42
2,4-Di-tert-butylphenol	Phenolics	5.86	6.55
2-Hydroxycyclopentadecanone	Ketones	n.d	0.88

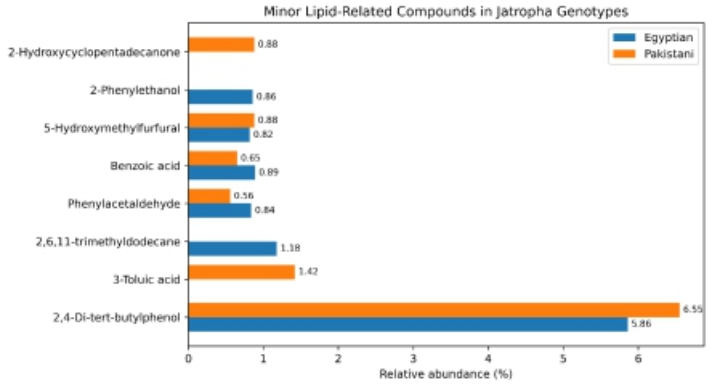

Figure 10: Comparative abundance of minor lipid-related compounds identified by GC–MS in Egyptian and Pakistani Jatropha seed genotypes

Lipid distribution

The overall distribution of lipid compounds in the seed extracts of the Pakistani and Egyptian genotypes is summarized in Table 7 and depicted in Figure 11. The unsaturated fatty acid compound was the majority lipid fraction, representing 56.26 and 54.61% of the total identified compounds in the Pakistani and Egyptian materials, respectively. The second largest group was saturated fatty acids, which comprised 19·07% in the Pakistani genotype and 18·69% in the Egyptian genotype. Hydrocarbons were also identified in a lower percentage in Egyptian seed extract (1.18%), and it did not exist in the Pakistani genotype. Overall, both seed extracts were dominated by high concentrations of unsaturated fatty acids, saturated fatty acids, and glycerolipid derivatives. Lipid compounds are significantly involved in energy storage, maintenance of cell membrane structure, and support of many physiological processes. Their relatively high proportion of polyunsaturated fatty acids may have to do with their role in maintaining flexible membranes and also acting as an energy source during seed maturation and germination [53]. They also have a role in helping plants to withstand environmental stresses. On the other hand, saturated fatty acids are associated with lipid stability, which might prevents the degradation of seed reserve during storage. Glycerolipid derivatives not only indicates that the lipid has been metabolised and that the energy is being stored efficiently in the seeds [54].

Table 7: Overall lipidomic profile distributed in both genotype seed extractions

Lipid class	Egyptian	Pakistani
Unsaturated fatty acids	54.61	56.26
Saturated fatty acids	18.69	19.07
Fatty acids esters	6.92	10.18
Phenolic compounds	9.27	8.64
Aromatic aldehydes/acids	1.66	2.86
Ketones+sterols+amides	1.48	1.74
Hydrocarbons	1.18	n.d

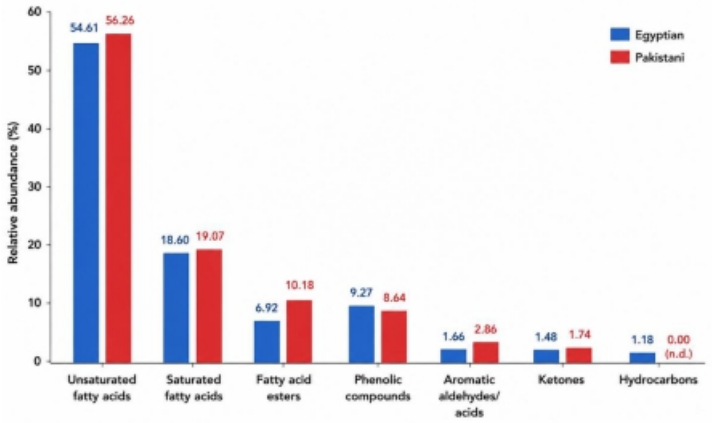

Figure 11. Overall lipidomic profile distribution (%) among major lipid classes in Egyptian and Pakistani Jatropha seed extracts.

Conclusion

Both Egyptian and Pakistani genotypes of Jatropha seeds are lipid-rich and are likely mainly consisting of fatty acids and their derivatives as shown by GC–MS analysis. Both genotypes consisted of linoleic acid as the major component, indicating the importance of unsaturated fatty acids on seeds of Jatropha. Additionally, we also observed the expression of glycerides, fatty acid esters, phytosterols, fatty aldehydes, and fatty amides, indicating an active lipid metabolism and efficient energy storage system. Despite no significant variability between the two genotypes, both were profuse in molecules that could be favorable in lipid profiles. High contents of unsaturated fatty acids and lipid derivatives suggest that can be used to improve seed vigour and germination, as well as industrial applications, particularly biodiesel and value-added products.

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