ISSN: 2621-4709 E-ISSN: 2621-2528
Journal of Applied Agricultural Science and Technology
Vol. 10 No. 3 (2026): 578-591

Fatty Acid Profile Comparison of Several Palm Cooking Oils Using Gas Chromatography–Flame Ionization Detection (GC–FID)

Susi Desminarti [a], Nela Eska Putri [a,*], Prima Yaumil Fajri [a]

[a] Food Engineering Technology Program, Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Indonesia

Abstract. *Palm cooking oil is the primary source of vegetable oil widely consumed by the Indonesian population. The fatty acid profile of palm oil is an important parameter for assessing its nutritional value, oxidative stability during heating, and potential health implications. Variations in refining and fractionation processes, as well as differences in raw material sources, may lead to diversity in the fatty acid composition of commercially available cooking oils. This study aims to analyze and compare the profiles of saturated, unsaturated, cis–trans, and omega fatty acids in different commercial palm cooking oil brands. Five palm cooking oil samples available on the market were analyzed, consisting of four packaged oils (MG1–MG4) and one bulk oil (MG5). Fatty acid profiling was conducted using Gas Chromatography–Flame Ionization Detector (GC-FID) following derivatization into Fatty Acid Methyl Esters (FAME) via $NaOCH_3$–methanol transesterification. Fatty acids were identified and quantified by comparing retention times and chromatographic peak areas using the normalization method. The results showed that total saturated fatty acids ranged from 39.96 to 43.76%, dominated by palmitic acid (34.27–37.65%). Unsaturated fatty acids accounted for 56.18–59.98% of total fatty acids, with oleic acid (44.50–46.16%) and linoleic acid (11.18–13.14%) as the major components. Omega fatty acids were predominantly represented by omega-9, followed by omega-6, while omega-3 fatty acids were detected at very low levels. No trans fatty acids were detected in any of the samples. Overall, the fatty acid profiles of the analyzed palm cooking oils were consistent with those of commercially refined palm oil, characterized by oleic acid predominance, a relatively balanced proportion of saturated and unsaturated fatty acids, and the absence of trans fatty acids. These features support good oxidative stability and are suitable for consumption.*

Keywords: *Fatty ~~acids~~ profile; GC-FID; palm cooking oil; oxidative stability.*

Type of the Paper: Regular Article.

1. Introduction

Palm oil is the most widely produced vegetable oil globally, with total output reaching 77.56 million tons in the 2022/2023 marketing year. This volume accounts for approximately 39% of global vegetable oil production (including palm kernel oil), surpassing soybean oil, which contributes around 28%. Indonesia, the world's leading producer, supplies approximately 46.50 million tons, representing nearly 59% of total global production [1]. In Indonesia, palm oil dominates the cooking oil sector, holding an estimated 90% market share and serving as the primary frying medium for household consumption. Per capita consumption of palm cooking oil reached 10.75 kg per year in 2023 [2]. The fatty acid profile is a critical determinant of the

https://doi.org/10.55043/jaast.v10i3.546
Received January 19, 2026; Received in revised form June 27, 2026; Accepted August 13, 2026; Published August 21, 2026
* Corresponding author
Email: nelaeskaputri@gmail.com

nutritional quality of palm cooking oil, particularly regarding the balance between saturated and unsaturated fatty acids. Thermal processing of lipids promotes the formation of lipid oxidation products, which may pose risks to human health. The levels of these oxidation products rise markedly as the temperature increases from 100 to 200 °C [3]. The maturity of oil palm fruit affects oil yield and fatty acid composition. As fruit maturity increases, the proportion of fatty acid components also increases [4].

Gas chromatography coupled with flame ionization detection (GC–FID) is a widely employed analytical technique for the qualitative and quantitative determination of fatty acids in oils. It is a well-established and standardized method for determining fatty acid profiles in palm oil, typically after conversion to fatty acid methyl esters (FAME). The use of GC–FID and with Principal Component Analysis (PCA) has been shown to effectively differentiate crude palm oil (CPO) from mixtures containing used cooking oil, even at low contamination levels ranging from 2–5% [5].

Although numerous studies have examined the quality of palm cooking oil, most previous literature has focused on general chemical parameters, such as free fatty acid levels, peroxide value, and acid value, to evaluate deterioration or differences between packaged and bulk oils [6, 7]. However, data comparing the fatty acid profiles of various cooking oil products available on the commercial market remain limited [8]. Other studies generally focus on thermal stability during repeated frying or compared physical quality based on plastic and bottle packaging types [6,8]. Given the variability in quality caused by differences in raw material sources, refining processes, and the risk of adulteration in bulk oils [9], more precise analytical methods are needed to verify the consistency of fatty acid composition in cooking oils. This study aims to analyze and compare the fatty acid profiles of various palm cooking oil products and bulk oils available on the commercial market using gas chromatography–flame ionization detection (GC–FID).

2. Materials and Methods

2.1.Samples and Chemicals

The materials analyzed in this study comprised five commercially available palm cooking oil samples, including four packaged brands (MG1, MG2, MG3, and MG4) and one bulk palm cooking oil sample (MG5) obtained from the local market. All chemical reagents used were of analytical grade and included hexane, distilled water (aquadest), methyl tert-butyl ether (MTBE), a transesterification reagent, and a neutralization solution. The principal analytical instruments employed in this study were a gas chromatography system equipped with a flame ionization detector (GC-FID) 2 mL autosampler vials. Additional equipment included an analytical balance and a centrifuge. All analyses were conducted in duplicate.

2.2.Preparation of Fatty Acid Methyl Esters (FAME)

Fatty acid methyl esters (FAME) were prepared using the sodium methoxide–methanol ($NaOCH_3$–methanol) transesterification procedure [10]. Prior to analysis, a single-point working standard solution was prepared in hexane. Each oil sample was accurately weighed into a 20 mL screw-cap vial. Distilled water was added only to solid samples, whereas liquid oil samples did not require water addition. Subsequently, methyl tert-butyl ether (MTBE) and the transesterification reagent were added. The vial was briefly opened to allow the addition of hexane, followed by the addition of a neutralization solution. The mixture was then centrifuged to facilitate phase separation. The resulting organic phase was carefully transferred into a 2 mL vial for subsequent GC-FID analysis.

FAME analysis was performed using a GC-FID system under the following operating conditions: injection was performed in split mode, and separation was achieved using a DB FastFAME capillary column. The oven temperature was programmed with a linear gradient from 50 to 230 °C to ensure optimal resolution of fatty acid methyl esters. Eluted compounds were analyzed using a flame ionization detector (FID).

2.3.Identification and Quantification of Fatty Acids

Fatty acids ranging from C4 to C24 were identified by comparing the retention times of chromatographic peaks obtained from the samples with those of external fatty acid standards analyzed under identical conditions. Individual fatty acids were quantified using the normalization method, whereby the sum of all detected peak areas was assumed to represent 100% of the total fatty acid content in each sample. The proportion of each fatty acid in the injected sample was calculated using the following Eq. (1):

$$Injected\ fatty\ acid\ (\%) = \frac{\mathrm{Ai}}{\sum Ai} \times 100\% \qquad (1)$$

A_i : represents the chromatographic peak area corresponding to fatty acid component i,
$\sum A_i$: denotes the total peak area of all detected fatty acid components.

The total contents of saturated and unsaturated fatty acids in each oil sample were subsequently calculated using the following equation, according to Saraswanti Indo Genetech, (2023), Eq. (2) [11]:

$$\text{Fatty acid content (\%)} = \text{Injected fatty acid (\%)} \times \text{Total fat content (\%)} \qquad (2)$$

3. Results and Discussion

3.1. Saturated Fatty Acids

Saturated fatty acids (SFA) are long-chain fatty acids that lack double bonds, conferring distinctive physicochemical properties, such as relatively high melting points and enhanced oxidative stability in vegetable oils. The overall SFA levels were relatively consistent across brands, reflecting standardized processing practices in refined palm oil (refined, bleached, and deodorized/RBD palm olein), in which total SFA contents typically range from 41-44% [12,13]. Table 1 presents the saturated fatty acid contents of several palm cooking oil samples.

Table 1. Saturated fatty acid composition of five palm cooking oils samples.

No.	Fatty Acid	Content (%)				
		MG1	MG2	MG3	MG4	MG5
	Saturated fatty acid total	42.17	41.86	39.96	41.97	43.76
1	C 4:0 (Butyric acid)	-	-	-	-	-
2	C 6:0 (Caproic acid)	-	-	-	-	-
3	C 8:0 (Caprylic acid)	0.02	0.01	0.01	0.02	0.02
4	C 10:0 (Capric acid)	0.02	0.02	0.01	0.02	0.02
5	C 11:0 (Undecanoic acid)	-	-	-	-	-
6	C 12:0 (Lauric acid)	0.20	0.15	0.08	0.18	0.17
7	C 13:0 (Tridecanoic acid)	-	0.01	-	-	-
8	C 14:0 (Myristic acid)	0.90	0.90	0.76	0.87	0.82
9	C 15:0 (Pentadecanoic acid)	0.04	0.04	0.04	0.04	0.04
10	C 16:0 (Palmitic acid)	36.26	36.16	34.27	36.08	37.65
11	C 17:0 (Heptadecanoic acid)	0.08	0.08	0.08	0.08	0.09
12	C 18:0 (Stearic acid)	4.12	3.98	4.19	4.15	4.46
13	C 20:0 (Arachidic acid)	0.37	0.36	0.37	0.38	0.36
14	C 21:0 (Heneicosanoic acid)	-	-	-	-	-
15	C 22:0 (Behenic acid)	0.07	0.06	0.07	0.07	0.06
16	C 23:0 (Tricosanoic acid)	0.01	-	-	-	-
17	C 24:0 (Lignoceric acid)	0.08	0.09	0.08	0.08	0.07

Table 1 summarizes the saturated fatty acid composition of five palm cooking oil brands, with total SFA contents ranging from 39.96 to 43.76%. Saturated fatty acids were predominantly represented by palmitic acid (C16:0), followed by stearic acid (C18:0), myristic acid (C14:0), and lauric acid (C12:0).

According to previous studies, the total SFA levels observed in this study are comparable to those reported for commercial palm oil samples, with palmitic acid contents of approximately 36–37% in MG1, MG2, and MG4. In contrast, the lowest SFA content was observed in sample MG3 (approximately 34%), while the highest was recorded in MG5 (approximately 37.65%). Palmitic acid (C16:0) dominated the SFA composition in all samples, with concentrations ranging from 34.27 to 37.65% and accounting for more than 85% of the total SFA. These values are slightly lower than those typically reported for crude palm oil (CPO), which generally contains 42–47% palmitic acid, but are consistent with refined palm olein, in which removal of the solid fraction (palm stearin) reduces palmitic acid levels to approximately 38–43% [13,14,15]. Palm oil contains approximately 45% palmitic acid and 39% oleic acid [16].

The average stearic acid content across the five samples was approximately 4%. This fatty acid composition aligns with that of refined palm oil, which typically contains 40–50% saturated fatty acids, primarily palmitic acid (38–44%), stearic acid (3.7–5%), myristic acid (0.9–1.2%), and lauric acid (0.1–0.4%), along with relatively low levels of caprylic, capric, arachidic, behenic, and lignoceric acids [17–20].

Variations in the SFA profiles among the five samples may be attributed to differences in refining processes, fresh fruit bunch (FFB) varieties, or fruit maturity levels. Palmitic acid content in crude palm oil typically ranges from 42 to 47% and may slightly decrease following refining, reaching approximately 36–41% [12,16,19]. The contents of short-chain saturated fatty acids, such as C8:0–C10:0, were relatively low (0.01–0.02%) across all samples, closely resembling the fatty acid profile of palm mesocarp oil rather than that of palm kernel oil [20,21].

Several other studies have also reported that palm oil contains approximately 45.7% palmitic acid [22] and that this fatty acid may account for up to 50% of total saturated fatty acids [18]. In refined palm oil, palmitic acid has been consistently identified as the predominant constituent [23]. Furthermore, some references indicate that the consensus value for palmitic acid (C16:0) in palm oil is approximately 43.39% ± 0.39% [24].

The C16:0/C18:0 ratio observed in samples MG1–MG5 (8.18–9.09) indicates that, despite variations arising with differences in industrial fractionation intensity, all five samples maintain a chemical profile consistent with refined palm cooking oil standards. Furthermore, the absence of significant deviation in this ratio indicates no evidence of adulteration with used cooking oil or other vegetable oils.

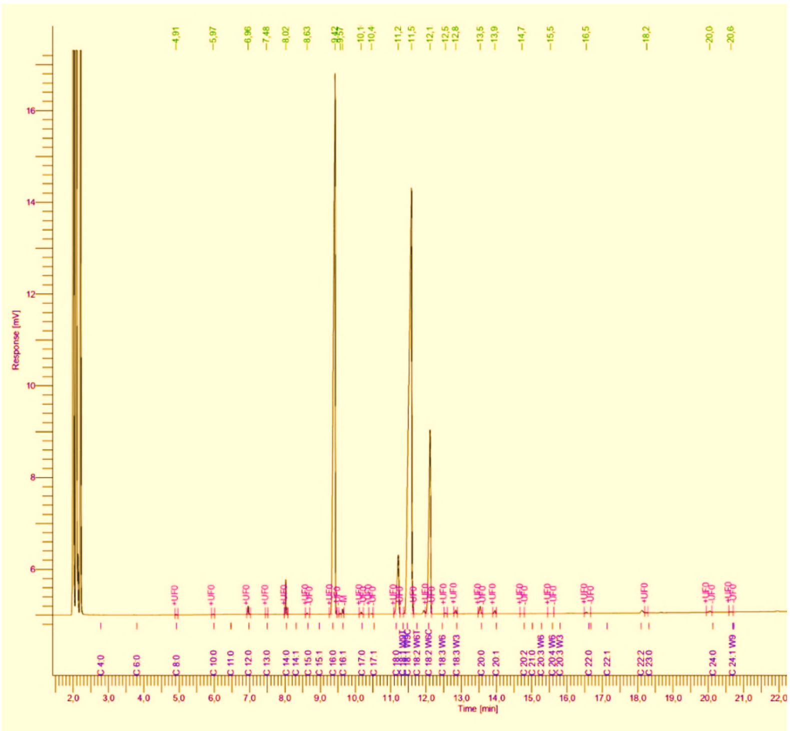
Table 2. Unsaturated fatty acid composition of several palm cooking oil samples.

No.	Fatty Acid	Content (%)				
		MG1	MG2	MG3	MG4	MG5
1.	Unsaturated Fatty Acid total	57.77	58.07	59.98	57.97	56.18
2.	Mono-Unsaturated Fatty Acid Total	46.10	45.98	46.50	45.94	44.81
	C 14:1 (Myristoleic acid)	-	-	-	-	-
	C 15:1 (Pentadecenoic acid)	-	-	-	-	-
	C 16:1 (Palmitoleic acid)	0.20	0.22	0.16	0.17	0.15
	C 17:1 (Heptadecenoic acid)	0.03	0.03	0.03	0.03	0.03
	C 18:1 Ω 9C (*cis-Oleic acid*)	45.72	45.58	46.16	45.59	44.50
	C 18:1 Ω 9T (*trans-Oleic acid*)	-	-	-	-	-
	C 20:1 (Eicosenoic acid)	0.15	0.15	0.15	0.15	0.13
	C 22:1 (Erucic acid)	-	-	-	-	-
	C 24:1 Ω 9 (Nervonic acid)	0.01	-	-	-	-
3.	Poly-Unsaturated Fatty Acid Total	11.67	12.08	13.49	12.03	11.37
	C 18:2 Ω 6C (*cis-Linoleic acid*)	11.47	11.91	13.14	11.84	11.18
	C 18:2 Ω 6T (*trans-Linoleic acid*)	-	-	-	-	-
	C 18:3 Ω 3 (α-Linolenic acid, ALA)	0.14	0.12	0.21	0.16	0.15
	C 18:3 Ω 6 (γ-Linolenic acid, GLA)	0.04	0.04	0.12	0.03	0.03
	C 20:2 (Eicosadienoic acid)	0.01	0.01	0.01	0.01	0.01
	C 20:3 Ω 3 (Eicosatrienoic acid / Ω 3)	0.01	-	0.01	-	-
	C 20:3 Ω 6 (Eicosatrienoic acid / Ω 6)	-	-	-	-	-
	C 20:4 Ω 6 (Arachidonic acid)	-	-	-	-	-
	C 20:5 Ω 3 (Eicosapentaenoic acid, EPA)	-	-	-	-	-
	C 22:2 (Docosadienoic acid)	-	-	-	-	-
	C 22:6 Ω 3 (Docosahexaenoic acid, DHA)	-	-	-	-	-

3.2. Unsaturated Fatty Acids

Unsaturated fatty acids contain one or more double bonds and are classified as monounsaturated fatty acids, which possess a single double bond, such as oleic acid, and polyunsaturated fatty acids, which contain two or more double bonds, such as linoleic and linolenic acids [18,25,26]. The unsaturated fatty acid contents of several palm cooking oil samples are presented in Table 2.

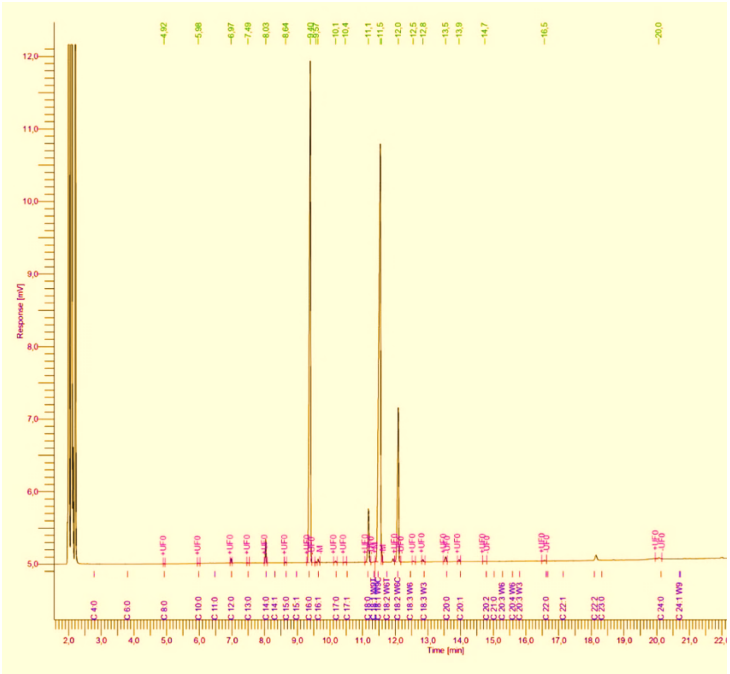
Table 2 shows that the total unsaturated fatty acid (UFA) content ranged from 56.18 to 59.98%. The dominant MUFA was C18:1 ω9 cis (oleic acid), followed by C16:1 (palmitoleic acid), C20:1 (eicosenoic acid), C17:1 (heptadecenoic acid), and C24:1 ω9 (nervonic acid). Within the PUFA fraction, C18:2 ω6 cis (linoleic acid) was the predominant component, followed by C18:3 ω3 (linolenic acid), C18:3 ω6, C20:2 (eicosadienoic acid) and C20:3. The chromatograms of each analyzed sample are presented in Fig. 1–5 to provide a comprehensive visualization of the fatty acid profiles obtained by GC–FID. This enables direct comparison of peak distributions and relative compositions among different palm cooking oil samples. The unsaturated Fatty Acid composition observed in this study (Table 2) agrees with previous studies of refined palm oil, which typically contains 40–45% MUFA (predominantly oleic acid at 39–45%) and 10–13% PUFA (mainly linoleic acid) [12,16,18,19,25].



Note: This image uses a comma as the decimal separator.

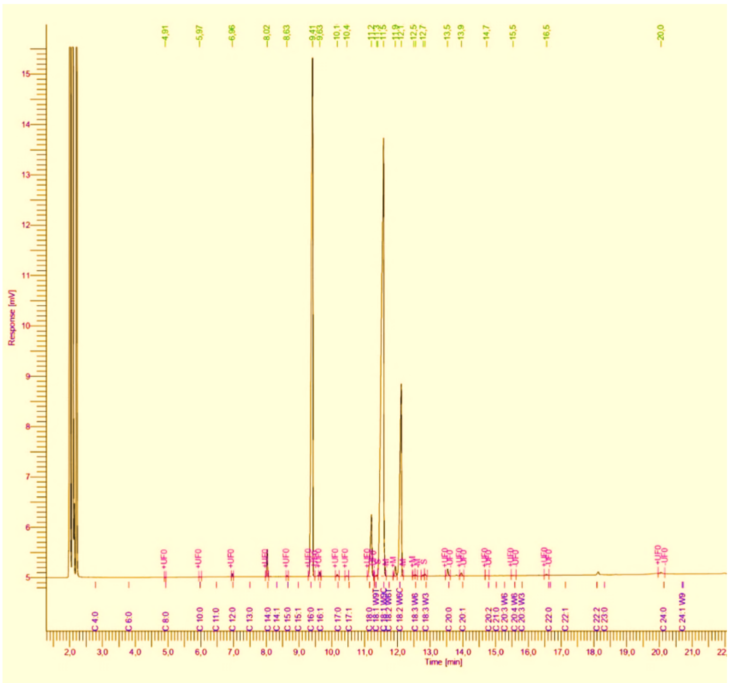
Fig.1. GC–FID chromatograms of MG1 of fatty acid methyl esters (FAMEs) with major peaks identified, including palmitic acid (C16:0), oleic acid (C18:1), and linoleic acid (C18:2).

MG3 exhibited the highest UFA content and MUFA level, predominantly contributed by oleic acid, and tended to highest PUFA content, primarily derived from linoleic acid. In contrast, MG5 tended to have the lowest values for all three parameters. These variations may be attributed to differences in refining processes and palm fruit sources, as palmitoleic acid levels in commercial palm olein have been reported to range from 0.097 to 0.318%, with oleic acid typically around 44–45%, consistent with the observed C16:1 and C20:1 contents in the present samples [12,19]. The absence of trans fatty acids and long-chain PUFA (such as EPA and DHA) in all samples further indicates the stability of the palm oil refining process [12,27].



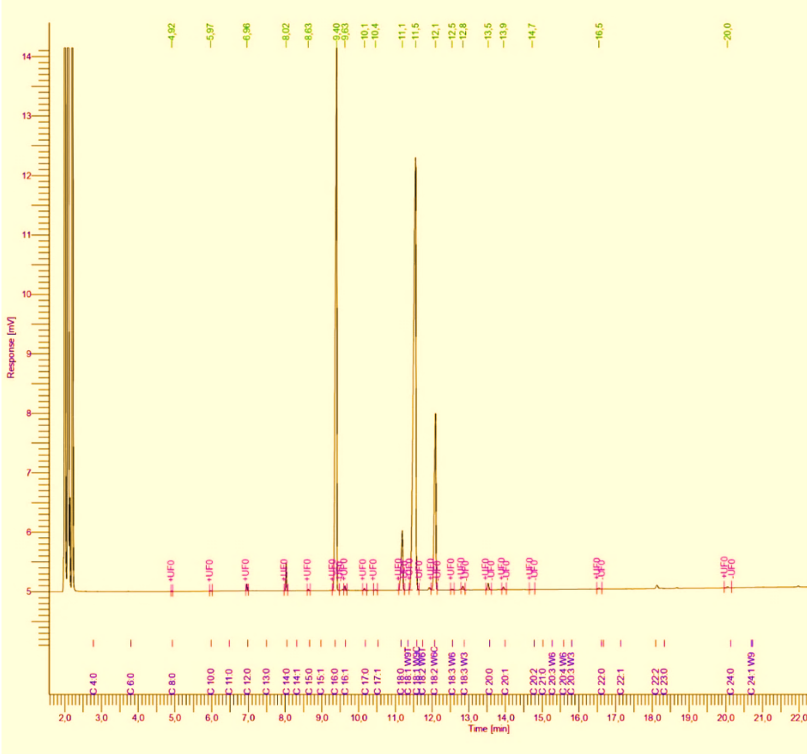
Note: This image uses a comma as the decimal separator.

Fig.2. GC–FID chromatograms of MG2 of fatty acid methyl esters (FAMEs) with major peaks identified, including palmitic acid (C16:0), oleic acid (C18:1), and linoleic acid (C18:2).



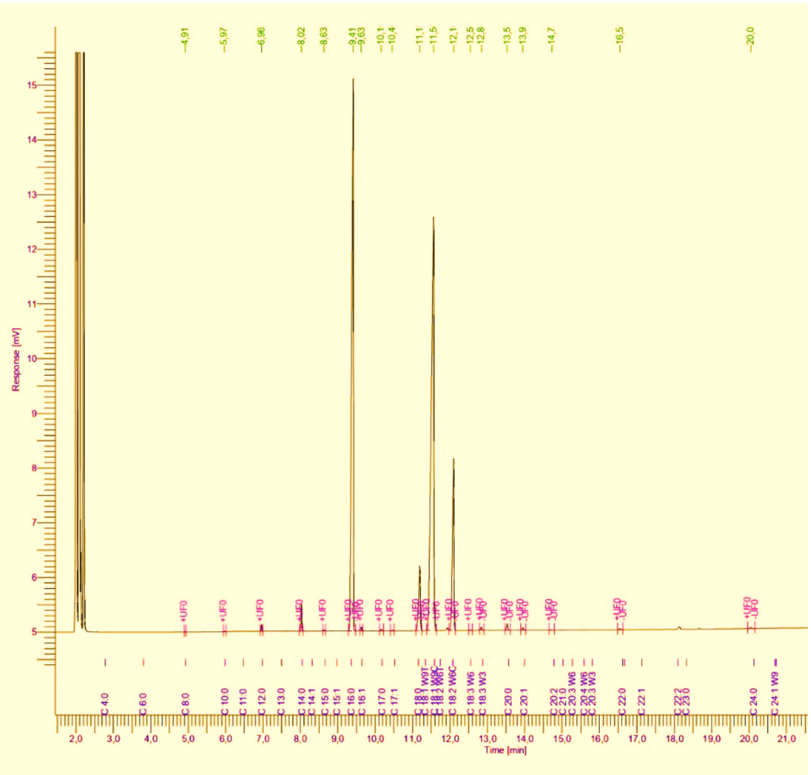
Note: This image uses a comma as the decimal separator.

Fig. 3. GC–FID chromatograms of MG3 of fatty acid methyl esters (FAMEs) with major peaks identified, including palmitic acid (C16:0), oleic acid (C18:1), and linoleic acid (C18:2).



Note: This image uses a comma as the decimal separator.

Fig. 4. GC–FID chromatograms of MG4 of fatty acid methyl esters (FAMEs) with major peaks identified, including palmitic acid (C16:0), oleic acid (C18:1), and linoleic acid (C18:2).



Note: This image uses a comma as the decimal separator.

Fig. 5. GC–FID chromatograms of MG5 of fatty acid methyl esters (FAMEs) with major peaks identified, including palmitic acid (C16:0), oleic acid (C18:1), and linoleic acid (C18:2).

Overall, all five samples exhibited high oleic acid contents, which contribute to oxidative stability of commercial palm cooking oils, along with moderate PUFA levels that support essential nutritional functions despite their higher susceptibility to oxidation. This profile aligns with the characteristic fatty acid composition of palm oil [12,16,18,25].

3.3.Omega Fatty Acids

Omega fatty acids are classified based on the position of the first double bond from the methyl terminus (terminal methyl, ω or n−) of the hydrocarbon chain. Omega-3 (n−3) fatty acids have their first double bond at the third carbon, omega-6 (n−6) at the sixth carbon, and omega-9 (n−9) at the ninth carbon from the methyl end [28,29,30,31]. These groups belong to the unsaturated fatty acids (UFA), with omega-3 and omega-6 classified as polyunsaturated fatty acids, and omega-9 classified as monounsaturated fatty acids, such as oleic acid (C18:1 n−9) [28, 31,32,33]. Table 3 presents the contents of omega-3, omega-6, and omega-9 fatty acids in the five palm cooking oil samples.

Table 3. Omega-3, omega-6, and omega-9 fatty acid content of five palm cooking oil brands.

No.	Fatty Acid	Content (%)				
		MG1	MG2	MG3	MG4	MG5
1.	Omega-3 Fatty Acids total	0.15	0.12	0.21	0.16	0.15
	C 18:3 Ω 3 (α-Linolenic acid/ Ω 3)	0.14	0.12	0.21	0.16	0.15
	C 20:3 Ω 3 (Eicosatrienoic acid/ Ω 3)	0.01	-	0.01	-	-
	C 20:5 Ω 3 (Eicosapentaenoic acid, EPA)	-	-	-	-	-
	C 22:6 Ω 3 (Docosahexaenoic acid, DHA)	-	-	-	-	-
2.	Omega-6 Fatty Acids total	11.51	11.95	13.27	11.87	11.21
	C 18:2 Ω 6 (Linoleic acid / Ω 6)	11.47	11.91	13.14	11.84	11.18
	C 18:3 Ω 6 (γ-Linolenic acid/ Ω 6)	0.04	0.04	0.12	0.03	0.03
	C 20:3 Ω 6 (Eicosatrienoic acid/ Ω 6)	-	-	-	-	-
	C 20:4 Ω 6 (Arachidonic acid)	-	-	-	-	-
3.	Omega-9 Fatty Acids total	45.73	45.58	46.16	45.59	44.50
	C 18:1 Ω 9C (*cis-Oleic acid*)	45.72	45.58	46.16	45.59	44.50
	C 24:1 Ω 9 (Nervonic acid)	0.01	-	-	-	-

Table 3 presents the omega fatty acid profiles of five palm cooking oil brands (MG1–MG5) analyzed using GC-FID, showing relatively low total omega-3 fatty acid contents ranging from 0.12 to 0.21%. Omega-3 fatty acids were primarily represented by C18:3 (linolenic acid) and C20:3. Total omega-6 fatty acid contents were substantially higher, ranging from 11.21 to 13.27%, predominantly contributed by C18:2 (linoleic acid), followed by C18:3 (γ-linolenic acid). Overall, the PUFA contents of these palm cooking oil samples align with previous reports [18, 34], which indicate PUFA levels of approximately 10–12% in palm oil.

Total omega-9 fatty acid contents ranged from 44.50 to 46.16%, almost entirely derived from C18:1 (oleic acid), with a minor contribution from C24:1 (nervonic acid). These findings align with those reported [16,18,34], which showed omega-9 contents of 44.78–46.54% in palm cooking oil. Commercial palm oil typically contains 37–45% oleic acid, which constitutes the major MUFA component contributing to oxidative stability.

Inter-brand variations were relatively small (Table 3), with MG3 exhibiting the highest total omega-3 and omega-6 contents, while MG5 showed the lowest omega-9 level. These differences may be attributed to variations in refining processes and fresh fruit bunch sources. According to Sujadi et al. [34], crude palm oil typically contains approximately 37–38% oleic acid and 9.9–10.9% linoleic acid.

Overall, the observed profile closely resembles that of palm oil, characterized by low omega-3, moderate omega-6, and high omega-9 contents. This profile supports the oxidative stability of palm cooking oil despite a relatively high omega-6: omega-3 ratio [18,35]. These findings align with the standards for commercial palm oil in Indonesia and Southeast Asia [16].

3.4.Cis-trans Fatty Acids

Cis–trans fatty acids are geometric isomers of unsaturated fatty acids. In the cis configuration, the double bond introduces a bend in the carbon chain, whereas the trans configuration adopts a more linear structure and is typically formed during high-temperature processing, such as deodorization (temperatures >240 °C) and frying. Table 4 presents the cis and trans fatty acid contents of the five palm cooking oil samples.

Table 4. Cis and trans fatty acids content of five palm cooking oil brands.

No.	Fatty acid	Content (%)				
		MG1	MG2	MG3	MG4	MG5
1.	C 18:1 Ω 9C (*cis*-Oleic acid)	45.72	45.58	46.16	45.59	44.50
	C 18:1 Ω 9T (*trans*- Oleic acid)	-	-	-	-	-
2.	C 18:2 Ω 6C (*cis*-Linoleic acid)	11.47	11.91	13.14	11.84	11.18
	C 18:2 Ω 6T (*trans*-Linoleic acid)	-	-	-	-	-

Table 4 presents the profiles of the major cis and trans fatty acid isomers in five palm cooking oil brands (MG1–MG5) analyzed using GC-FID. The content of C18:1 ω9 cis (cis-oleic acid) ranged from 44.50 to 46.16%, with the MG3 showing the highest value and MG5 the lowest. Similarly, C18:2 ω6 cis (cis-linoleic acid) was present at levels of 11.18–13.14%, with MG3 showing the highest content and MG5 the lowest.

The observed cis-oleic and cis-linoleic acid contents are comparable to those reported for commercially refined palm oil, in which cis-oleic acid typically accounts for 39–45% and cis-linoleic acid for 10–11%, with the unsaturated fatty acid fraction predominantly composed of cis isomers and minimal or no trans isomers [14,16,18]. The absence of trans fatty acids in these samples indicates that substantial trans isomerization did not occur during processing and is consistent with the absence of partial hydrogenation.

MG3 exhibited the highest cis isomer contents (C18:1 cis and C18:2 cis), followed by MG2 (45.58% and 11.91%), while MG5 showed the lowest levels. Inter-brand variation was less than 2%, which may be attributed to differences in fractionation processes or processing conditions. Overall, the inter-brand variability was relatively homogeneous, with MG3 consistently exhibiting the highest cis-oleic and cis-linoleic acid contents, reflecting standardized industrial processing without significant cis–trans isomerization [14]. The absence of trans fats further indicates the high quality of these commercial products, in contrast to partially hydrogenated oils, which may contain 2–30% trans fatty acids in waste oil or palm fatty acid distillate (PFAD) as a result of extreme thermal exposure [36,37].

4. Conclusions

The analysis of fatty acid profiles of five palm cooking oil samples using GC-FID revealed that all samples exhibited relatively uniform fatty acid compositions consistent with commercially refined palm oil. Total saturated fatty acids accounted for approximately 39.96–43.76% and were dominated by palmitic acid, while unsaturated fatty acids consist of oleic acid and linoleic acid as the major components. Omega fatty acids were predominantly represented by omega-9, followed by omega-6, whereas omega-3 fatty acids were detected at very low levels. No trans fatty acids were detected in any of the samples. Overall, these findings confirm that both packaged and bulk oils available palm cooking oils possess fatty acid profiles that meet industry standards and exhibit good oxidative stability.

Abbreviations

CPO	Crude palm oil
FID	Flame Ionization Detector
FAME	Fatty Acid Methyl Esters
GC	Gas chromatography
MUFA	Monounsaturated fatty acids
PUFA	Polyunsaturated fatty acids
SFA	Saturated fatty acid

Data Availability Statement

Data will be made available on request.

CRediT Authorship Contribution Statement

Susi Desminarti: Conceptualization, Methodology, Resources, Formal analysis, Investigation, Data curation, Funding acquisition, Writing–review. **Nela Eska Putri**: Conceptualization, Methodology, Resources, Investigation, Data curation, Funding acquisition, Writing – review & editing. **Prima Yaumil Fajri**: Conceptualization, Methodology, Resources, Investigation, Data curation, Funding acquisition, Writing–review.

Declaration of Competing Interest

The authors of this manuscript declare no conflict of interest or competing interest.

Declaration of Use of AI in the Writing Process

The authors acknowledge the use of artificial intelligence (AI) tools to support the preparation of this manuscript. In particular, Jenni AI and ChatGPT were employed to assist with language editing, grammatical correction, and enhancing the clarity and readability of the manuscript. After using the tools, the authors carefully reviewed and edited the content and take full responsibility for the content of the publication.

Acknowledgement

This research was funded in part of the research cluster of Politeknik Pertanian Negeri Payakumbuh in 2025.

References

[1] Ostfeld R, Reiner DM. Seeing the forest through the palms: developments in environmentally sustainable palm oil production and zero-deforestation efforts. J Frontiers in Sustainable Food Systems 2024;8:1–7. https://doi.org/10.3389/fsufs.2024.1398877

[2] Kementerian Pertanian Republik Indonesia. Outlook Komoditas Perkebunan Kelapa awit. Pusat Data dan Informasi Pertanian Sekretariat Jenderal Kementerian Pertanian Indonesia 2024. https://satudata.pertanian.go.id/details/publikasi/696

[3] Zhuang Y, Dong J, He X, Wang J, Li C, Dong L, Zhang Y, Zhou X, Wang H, Yi Y, Wang S. Impact of heating temperature and fatty acid type on the formation of lipid oxidation product during thermal processing. Frontiers in Nutrition 2022;9:1–10. doi:10.3389/fnut.2022.913297

[4] Islamiah S, Rezeki S, Ivontianti WD. Studi pengaruh Tingkat kematangan buah kelapa sawit terhadap kandungan asam lemak melalui metode maserasi. Rafflesia Journal of Natural and Applied Sciences 2021;1:40–9. https://doi.org/10.33369/rjna.v1i1.15602

[5] Inthiram AK, Mirhosseini H, Tan CP, Mohamad R, Lai OM. Application of multivariate analysis for detection of crude palm oil adulteration through fatty acid composition and triacylglycerol profile. Pertanika Journal Tropical Agricultural Science 2015;38:389–98. https://openurl.ebsco.com/EPDB%3Agcd%3A4%3A17069476/detailv2?sid=ebsco%3Aplink%3Acrawler-gcd&id=ebsco%3Agcd%3A109346715&crl=c&jrnl=15113701&link_origin=scholar.google.com

[6] Amanda TD, Firdaus ML, Nursaadah E, Nurhamidah, Ruyani A. Effect of high temperature heating on free fatty acid content and peroxide number of packaged and bulk palm cooking oil. AcTion: Aceh Nutrition Journal 2026;11:272–82. http://dx.doi.org/10.30867/action.v11i1.3158 https://www.researchgate.net/publication/402631476_Effect_of_high_temperature_heating_on_free_fatty_acid_content_and_peroxide_number_of_packaged_and_bulk_palm_cooking_oil

[7] Lika LCR, Luhtansa SS, Blaon SB, Panjaitan RS. Comparison of acid numbers in bulk and packaged cooking oil samples. Indonesian Journal of Pharmaceutical Research 2022;2:22–6. https://doi.org/10.31869/ijpr.v2i2.4155

[8] Hassim NAM, Ismail NH, Kanagaratnam S, Isa WRA, Dian NLHM. Quality of commercial palm-based cooking oil packaged in plastic pouch and polyethylene terephthalate (PET) bottle. Journal of Oil Palm Research 2020;33:493–513. https://doi.org/10.21894/jopr.2020.0089

[9] Igile GO, Iwara AI, Ekpe OO, Essien NM, Egbung GE. Quality evaluation of low free fatty acid and high free fatty acid crude palm oil and variation of total fatty matter and fatty acid composition in Nigerian palm oil. African Journal of Biotechnology 2023;22:247–56. doi.org/10.5897/AJB2020.17181

[10] Liu K. Preparation of fatty acid methyl esters for gas-chromatographic analysis of lipid in biological materials. A review. JAOCS 1994;71:11:1179-87. https://doi.org/10.1007/BF02540534

[11] (SIG) Saraswanti Indo Genetech. Metode uji asam lemak jenuh dan tak jenuh secara GC 2023.

[12] Loganathan R, Tarmizi AHA, Vethakkan SR, Teng K. Storage stability assessment of red palm olein in comparison to palm olein. Journal of Oleo Scienc 2020;1163–79. https://www.jstage.jst.go.jp/article/jos/69/10/69_ess20036/_pdf/-char/en
[13] Tan CH, Lee CJ, Tan SN, Poon DTS, Chong CYE, Pui LP. Red palm oil: a review on processing, health benefits and its application in food. Journal of Oleo Science 2021;1–10. https://www.jstage.jst.go.jp/article/jos/70/9/70_ess21108/_pdf/-char/en
[14] Ng JS, Muhammad SA, Ibrahim B, Rafatullah M, Strashnov I, Yong Ch et al. Fatty acid diagnostic ratios to screen for used oil adulteration in refined, bleached, deodorised palm oil. Food Analytical Methods 2025;18:1685–98. https://doi.org/10.1007/s12161-025-02815-w.
[15] Nizam AFA, Mahmud MS. Food quality assurance of crude palm oil: a review on toxic esterfeedstock Food quality assurance of crude palm oil: a review on toxic esterfeedstock. OCL 2021;28:14–23. https://doi.org/10.1051/ocl/2021011.
[16] Kasmin H, Lazim AM, Awang R. Determination of fatty acid composition and quality characteristics of oils from palm fruits using solvent extraction 2015. https://doi.org/10.1063/1.4931281
[17] Kostik V, Memeti S, Bauer B. Fatty acid composition of edible oils and fats fatty acid composition of edible oils and fats. Journal of Hygienic Engineering and Design UDC 112–6. https://eprints.ugd.edu.mk/11460/1/06.%20Full%20paper%20-%20Vesna%20Kostik%202.pdf
[18] Koushki M, Nahidi M, Cheraghali F. Physico-chemical properties, fatty acid profile and nutrition in palm oil. Archives of Advances in Biosciences 2015;6:117–34. https://doi.org/10.22037/jps.v6i3.9772
[19] Lisa SA, Khan S, Kabir MA, Islam F, Mohajan S, Chowdhury K. Quality and vitamin A status assessment of different commercial edible oil. Bangladesh Journal of Scientific and Industrial Research 2019;54:11–20. https://doi.org/10.3329/bjsir.v54i1.40726.
[20] Urugo MM, Teka TA, Teshome PG, Tringo TT. Palm oil processing and controversies over its health effect: overview of positive and negative consequences palm oil processing and controversies over its health effect: Overview of positive and negative consequences. Journal of Oleo Science Journal of Oleo Science 2021;9:1693–1706. https://www.jstage.jst.go.jp/article/jos/70/12/70_ess21160/_pdf/-char/en
[21] Elombo FK, Damme EV, Delepine C, Depraetere D, Chaveriat L, Keilah PL et al. Cosmetic or dietary vegetable oils sampled in the cameroonian market may not expose consumers to lipid oxidation products generating oxidative stress and inflammation. American Journal of Plant Sciences 2024;15:192–202. https://www.scirp.org/pdf/ajps2024153_42605754.pdf
[22] Bahadi MA, Salimon J, Japir AM. The physicochemical and thermal properties of Malaysian high free fatty acid crude palm oil. AIP Conf Proc 2016;1784. https://doi.org/10.1063/1.4966740
[23] Mancini A, Imperlini E, Nigro E, Montagnese C, Orrù S, Buono P. Biological and nutritional properties of palm oil and palmitic acid: effects on health. Molecules 2015;20:17339–61. https://doi.org/10.3390/molecules200917339.
[24] Tarmizi AHA, Lin SW, Kuntom A. Development of palm-based reference materials for the quantification of fatty acids composition. Journal of Oleo Science 2008;57: 275–285. https://doi.org/10.5650/jos.57.275
[25] Igile GO, Iwara AI, Ekpe OO, Essien NM, Egbung GE. Quality evaluation of low free fatty acid and high free fatty acid crude palm oil and variation of total fatty matter and fatty acid composition in Nigerian palm oil. Academic Journals 2023;22:247–56. https://academicjournals.org/journal/AJB/article-full-text-pdf/4F7406071304
[26] Tan C, Nehdi IA. 13 - The physicochemical properties of palm oil and its components. J Palm Oil 2012:377–91. https://doi.org/10.1016/B978-0-9818936-9-3.50016-2.
[27] Memon HD, Sherazi STH, Mahesar SA, Shoaib H, Malghani NA. Chemometric approach for the evaluation of quality and thermo-oxidative stability of soybean, palm olein and canola

oils and their blends. J Oleo Sci 2023;72:667–80. https://pubmed.ncbi.nlm.nih.gov/37380483/
[28] Asif M. Health effects of omega-3,6,9 fatty acids: Perilla frutescens is a good example of plant oils. Oriental Pharmacy & Experimental Medicine 2011;11:51–9. https://link.springer.com/content/pdf/10.1007/s13596-011-0002-x.pdf
[29] Kerr BJ, Kellner TA, Shurson GC. Characteristics of lipids and their feeding value in swine diets. Kerr et al. Journal of Animal Science and Biotechnology 2015;6:30. https://link.springer.com/content/pdf/10.1186/s40104-015-0028-x.pdf
[30] Kołodziejczyk M, Bułdak L, Maciej BO. Polyunsaturated fatty acids in reducing cardiovascular risk. Pediatr Med Rodz 2021;17:27–35. https://doi.org/10.15557/PiMR.2021.0004.
[31] Saini RK, Keum Y. Omega-3 and omega-6 polyunsaturated fatty acids: Dietary sources, metabolism, and significance-A review. Life Sciences 2018;203:255–67. https://doi.org/10.1016/j.lfs.2018.04.049
[32] Abedi E, Sahari MA. Long-chain polyunsaturated fatty acid sources and evaluation of their nutritional and functional properties. Food Sciences & Nutritions 2014;443–63. https://doi.org/10.1002/fsn3.121
[33] Chang C, Nickerson MT. Encapsulation of omega 3-6-9 fatty acids-rich oils using protein-based emulsions with spray drying. J Food Sci Technol 2018;55:2850–61. https://doi.org/10.1007/s13197-018-3257-0
[34] Sujadi S, Hasibuan HA, Rivani M, Purba AR. Oil content and chemical composition in the parts of oil palm fruit from 8 IOPRI varieties. Indonesian Journal of Oil Palm Research 2016;24:67–76. https://doi.org/10.22302/iopri.jur.jpks.v24i2.9 https://jurnalkelapasawit.iopri.org/index.php/jpks/article/view/9
[35] Ahmed R, Haq M, Cho Y, Chun B. Quality evaluation of oil recovered from by-products of bigeye tuna using supercritical carbon dioxide extraction. Turkish Journal of Fisheries and Aquatic Sciences 2017;14:663–72. https://doi.org/10.4194/1303-2712-v17_4_02
[36] Artiga A, Almirall XO, Puig FB, Diaz-Ferrero J. Development of a GC-FID method for the analysis of fatty acids in palm olein to study the formation of C18:1 trans during deep discontinuous frying processes in El Salvador food industry. Afinidad IQS-Journal of Chemical Engineering Theorethical and Applied Chemistry 2024;81:603. https://doi.org/10.55815/430521
[37] Punvichai T, Pioch D. Co-valorization of agro-industry by-products: effect of citrus oil on the quality of soap derived from palm fatty acid distillate and spent bleaching clay. Letters in Applied NanoBioScience 2019;8:571–5. https://doi.org/10.33263/LIANBS83.571575