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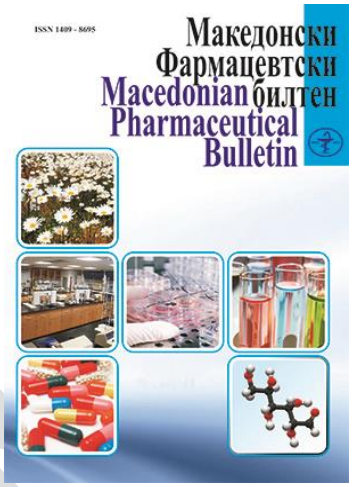

Title: Application of gas chromatography for determining fatty acid composition and authenticity of edible oils

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Application of gas chromatography for determining fatty acid composition and authenticity of edible oils

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Abstract

The quality and authenticity of edible oils represent key parameters in the food industry, directly influencing consumer health and the economic stability of the market. Fatty acid, methyl esters (FAMEs), the main constituents of edible oils, serve as biochemical indicators for assessing their origin, processing degree, and nutritional quality.

The increasing incidence of oil adulteration - where high-value oils are partially or entirely substituted with cheaper alternatives without proper declaration - there is a growing demand for precise and reliable analytical methodologies. To address this challenge, advanced chromatographic techniques have become essential tools for ensuring product traceability and authenticity.

Gas chromatography technique, coupled with flame ionization detector (GC–FID) represents one of the most effective techniques for the identification and quantification of fatty acids. Due to its high selectivity, sensitivity, and reproducibility, GC–FID enables the generation of characteristic chemical profiles for different oil types, facilitating the detection of adulterated, blended, or misdeclared products. Consequently, its application in monitoring

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edible oil quality and authenticity is of critical importance for regulatory agencies, manufacturers, and consumers alike.

The objective of this study is to establish and validate (verification) a GC–FID methodology for the determination of fatty acid composition in sunflower, olive, and palm oils. The proposed method demonstrates high analytical reliability and practical applicability under both industrial and laboratory conditions, offering a solid foundation for future standardization within food quality control systems.

Keywords: extra virgin olive oil, sunflower oil, palm oil, adulteration, fatty acid methyl esters, gas chromatography, GC-FID, quality assessment.

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Introduction

Edible fats and oils represent essential lipid materials for human nutrition/ consummation and are widely used in food processing and cosmetic formulations (Tian et al., 2023). They contain fat-soluble vitamins and varying proportions of saturated and unsaturated fatty acids. Chemically, these lipids are primarily composed of water-insoluble esters of fatty acids and glycerol, known as glycerides. At room temperature, fats are solid and oils are liquid. Based on their origin, they are classified as vegetable or animal. Vegetable oils are extracted from seeds or fruits of oil-bearing plants, while animal fats are obtained from adipose tissue or milk (Toishimanov et al., 2023). The nutritional quality of a lipid is largely determined by its degree of unsaturation—higher levels of polyunsaturated fatty acids generally indicate a more favorable nutritional profile. Oils, such as sunflower and olive oil are rich in unsaturated fatty acids and are often consumed in their natural form. In contrast, palm oil, with a higher content of saturated fatty acids, provides superior oxidative stability but lower nutritional value (Tan et al., 2021).

Sunflower oil is composed almost entirely of triglycerides, with oleic and linoleic acids as the predominant fatty acids. Oleic acid, a monounsaturated fatty acid of high biological importance, contributes to membrane integrity, while linoleic acid is an essential omega-6 fatty acid that must be supplied through the diet. Trace amounts of stearic, palmitic,

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myristic, and arachidonic acids further influence its physicochemical and nutritional properties (Teasdale et al., 2021).

Olive oil, obtained by mechanical pressing of olives (extra virgin), represents a central component of the Mediterranean diet. It is distinguished by its unique flavor, high nutritional value, and health-promoting effects. Fatty acids account for over 95% of its composition, with oleic acid (65–85%) being predominant. The high oleic content ensures oxidative stability and underpins its recognized functional and therapeutic benefits (González-Pereira et al., 2021).

Palm oil is rich in saturated fatty acids, primarily palmitic acid (40–45%), alongside notable proportions of oleic (39–45%), stearic, and linoleic acids. Its high saturation confers remarkable oxidative stability and resistance to rancidity, which accounts for its extensive industrial use in frying, baking, and processed food production (Zhang et al., 2014).

Fatty acid composition determines the functional, nutritional, and technological characteristics of edible oils. Although a higher degree of unsaturation enhances nutritional value, it also increases oxidative susceptibility. Therefore, accurate profiling of fatty acids is essential for evaluating oil quality, authenticity, and stability, as well as detecting potential adulteration (Aluyor et al., 2009, 2017; Guerrero-Esperanza et al., 2023).

In the Republic of North Macedonia, quality standards for edible vegetable oils and fats are defined under Article 117, paragraph (3) of the Food Safety Law (Official Gazette of the Republic of Macedonia, Nos. 157/10, 53/11, and 1/12). These standards regulate classification, labeling, physicochemical and organoleptic parameters, and the quality of raw materials and additives used in production.

The fatty acid profiles of sunflower, olive, and palm oils were determined using capillary gas chromatography with flame ionization detection (GC-FID) (Dimitrovska et al., 2020), a technique providing high sensitivity and reproducibility for both qualitative and quantitative lipid analysis (Rahman et al., 2024). Because free fatty acids are poorly volatile and thermally unstable, they are usually derivatized into fatty acid methyl esters (FAMEs) prior to analysis (Rahman et al., 2024).

Preparation of FAMEs is a crucial step in lipid analysis, allowing accurate determination of fatty acid composition. Among standardized methods, the AOCS Official

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Method Ce 2-66 is widely used to convert fatty acids from oils and fats into methyl esters. In this method, fatty acids in triglycerides or other lipid compounds are esterified with methanol in the presence of boron trifluoride (BF_3), producing methyl esters suitable for chromatographic identification and quantification. It applies to a wide range of lipid sources, including vegetable, animal, and microbial oils, as well as phospholipids and complex lipids, and is valued for its reproducibility and compliance with international standards (ISO 5509, AOAC 969.33).

However, BF_3–methanol has notable limitations: it is toxic, corrosive, chemically unstable, and can form hydrofluoric acid upon contact with moisture. It also has a short shelf life and may induce side reactions, such as isomerization or degradation of polyunsaturated fatty acids, potentially affecting analytical accuracy. Consequently, while historically important, AOCS Ce 2-66 is now mainly applied to samples with high free fatty acid content or complex lipid matrices.

Esterification can be performed under acidic or alkaline conditions depending on lipid composition and free fatty acid (FFA) content. Acid-catalyzed esterification, using sulfuric or hydrochloric acid in methanol, effectively converts free and bound fatty acids into methyl esters. This method is suitable for crude or unrefined oils with elevated FFA (>0.3%) but requires higher temperatures (60–100 °C), longer reaction times, and careful handling of corrosive reagents.

In contrast, alkaline-catalyzed transesterification uses bases such as KOH, NaOH, or sodium/potassium methoxide ($NaOCH_3$/$KOCH_3$) in methanol. It is most effective for neutral oils with very low FFA (<0.1–0.3%), such as refined sunflower, olive, or palm oils. This method offers several advantages: rapid reactions often at room temperature, high yields of methyl esters with minimal side reactions, mild conditions avoiding toxic reagents, and excellent compatibility with GC analysis due to the volatility and stability of FAMEs. Accordingly, alkaline methods are now preferred for routine GC analysis of refined oils.

The practical application of these approaches is illustrated in plant lipid studies. (Rafajlovska et al., 2001) converted fatty acids from *Urtica dioica* L. extracts obtained via supercritical CO_2 into FAMEs by esterification with a methanolic solution of sulfuric acid for subsequent GC-FID analysis. Similarly, (Đurović et al., 2017) extracted fatty acids from

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stinging nettle leaves with hexane, followed by hydrolysis and methanolic KOH esterification, yielding FAMEs suitable for chromatographic quantification. These studies highlight the flexibility of acid- and base-catalyzed esterification depending on the chemical profile of the lipid matrix.

The aim of this study is to determine and compare the fatty acid compositions of sunflower, olive, and palm oils by gas chromatography. The obtained data serve to assess the quality and authenticity of the analyzed samples, with particular emphasis on identifying potential adulteration in olive oil.

Materials and methods

Sample description

In this study, fatty acid analysis was performed on the following oil samples:

1. Refined sunflower oil, *Zolotaya Semechka* – Russia
2. Palm oil, *Palm Oil* – Malaysia
3. Cold-pressed olive oil, *Oleum Viride Belic* – Croatia
4. Cold-pressed olive oil, *Greta Eleon* – Greece
5. Cold-pressed olive oil (unbranded) from a private producer – Albania.

Chemicals / Reagents and Standards

The following chemicals and standards were used in this study:

1. Heptane (n-Heptane, 99%), Fisher Chemical, USA
2. Potassium hydroxide (KOH), Pro Analysis, Alkaloid, Skopje
3. Methanol, Pro Analysis, Alkaloid, Skopje
4. Restek FAME Mix C4–C24, concentration 30 mg/mL total in methylene chloride, 1 mL per ampule

The FAME standard used in this study had the composition shown in Table 1.

Table 1

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Preparation of FAMEs

The preparation of FAMEs from edible oils was performed according to the method described by Đurović et al. (2017).

In the procedure, a portion of 0.200 mL is dissolved in n-heptane, which serves as a nonpolar solvent that facilitates improved miscibility with the alcoholic phase. The addition of 0.1 mL of 2 N methanolic KOH initiates a base-catalyzed transesterification reaction, in which potassium hydroxide generates methoxide ions that react with the ester bonds of triglycerides. During this reaction, methanol replaces the glycerol moiety with a methyl group, resulting in the formation of fatty acid methyl esters (FAMEs), while glycerol remains in the lower (polar) phase.

Following vortex mixing for 30 seconds and subsequent standing for 30 minutes, clear phase separation is achieved. The upper organic layer contains the FAMEs dissolved in heptane, which are pipetted (0.2 mL) into vials and further diluted with 1 mL of heptane to obtain an appropriate concentration for GC-FID analysis. This method provides high reproducibility and minimal compound degradation, thereby enabling accurate quantitative determination of the fatty acid profile.

GC operating conditions

Instrumentation – The separation of these compounds was carried out using a PerkinElmer Clarus 690 GC system equipped with an integrated automatic liquid sampler, a capillary injector, and a flame ionization detector (FID).

Helium was employed as the carrier gas, while hydrogen and oxygen served as support gases for the detector. All chromatographic separations were performed on a capillary column (PerkinElmer Elite-2560) with dimensions of 100 m × 0.25 mm i.d. × 0.20 μm film thickness. The oven temperature anetmaximum of 240°C, following a three-step gradient (15°C/min to 170°C, 4°C/min to 220°C, and 2°C/min to 240°C with a final hold of 10 min). This gradual temperature ramp enables sequential elution of FAMEs according to their chain length and degree of unsaturation. The injector temperature (250°C) ensures rapid vaporization of the injected sample, while the detector temperature (300°C) provides complete combustion of the eluted compounds in the FID. The FID detects organic

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compounds based on the ionization of carbon atoms in a hydrogen-air flame, producing a signal proportional to the number of carbon atoms entering the detector per unit time. Consequently, the detector response is directly related to the concentration of individual FAMEs.

The detailed operating conditions of the instrument are summarized in Table 2**.**

Table 2

Fatty acids were identified based on the retention times of the standard fatty acid mix **(**Restek FAME Mix C4–C24). In the analyzed edible oils, the following fatty acids were detected: C16:0, C16:1, C18:0, C18:1, C18:2, and C18:3. The fatty acid composition was calculated as the percentage of individual fatty acids relative to the total fatty acids present in the edible oils.

Results and discussion

In this study, the analysis of thirty-seven fatty acid methyl esters (FAMEs), commonly found in edible oils and food matrices, was conducted. The separation of these compounds was achieved under the chromatographic conditions summarized in Table 2, and all FAMEs were successfully resolved. Their respective retention times are presented in Table 3.

Table 3

In line with regulatory standards for fats and oils, this study focused on the fatty acids most commonly present in the selected edible oils. A total of six fatty acid methyl esters (FAMEs) were analyzed, and their results are presented in Table 3.

The table below (see Table 4) presents the results of the fatty acid composition analysis of several types of vegetable oils. The oils included in this study are: refined sunflower oil, *Zolotaya Semechka* – Russia, palm oil, *Palm Oil* – Malaysia, cold-pressed

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olive oil, *Oleum Viride Belic* – Croatia, cold-pressed olive oil, *Greta Eleon* – Greece, cold-pressed olive oil (unbranded) from a private producer – Albania. Based on the obtained values, an assessment of their chemical composition can be made, including the evaluation of quality and the potential presence of undesirable components.

Table 4

The laboratory in which the analyzed oils were tested refers to the Rulebook published in the "Official Gazette of the Republic of Macedonia" No. 127/2012 concerning the quality and composition of fatty acids, with permitted minimum and maximum concentrations expressed in %. The permissible values for the main fatty acids are presented in Table 4.

Based on the results obtained for individual fatty acids (see Table 4), the presence of specific fatty acids in characteristic concentrations was observed.

In accordance with the relevant regulations and the official Rulebook, the analyzed oils were determined to possess compositions consistent with acceptable industrial quality standards. A satisfactory fatty acid profile was obtained for the sunflower oil sample, while the results for palm oil corresponded closely to the normative values specified in the Rulebook. The olive oil samples exhibited fatty acid compositions that were generally in line with the established quality criteria.

However, one of the analyzed olive oil samples — the unbranded sample originating from Albania — demonstrated fatty acid concentrations inconsistent with the characteristic composition of authentic olive oil. According to the regulation, olive oil should contain oleic acid (C18:1) in the range of 55–83%; yet, in the unbranded sample, the concentration was only 30.35%. Furthermore, linoleic acid (C18:2) in genuine olive oil should range from 3.5% to 21%, whereas in this non-compliant sample, a markedly higher concentration of 58.93% was determined. These deviations strongly indicate that the product was, in fact, sunflower oil misrepresented as olive oil.

The unbranded sample displayed substantial deviations from the compositional standards established by the official Rulebook, particularly regarding its unusually low oleic

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(C18:1) and abnormally high linoleic (C18:2) acid levels — both of which are key determinants of vegetable oil identity and quality. Additionally, palmitoleic acid (C16:1) was not detected in the sample, a finding slightly below the normative range for olive oil (0.3–3.5%) but consistent with the fatty acid profiles typically observed in sunflower and palm oils.

The compositional similarities between the unbranded olive oil sample ("palette") and sunflower oil are clearly evident (see Table 4). This substantial deviation from the expected fatty acid pattern of authentic olive oil suggests the presence of adulteration or deliberate blending with other, lower-cost oils.

Such findings underscore the importance of stringent quality control and authenticity verification of edible oils, particularly those distributed in bulk quantities or sourced from uncertified producers. Adulteration with cheaper oils such as sunflower or palm oil not only diminishes the nutritional and sensory value of the product but also constitutes a clear case of consumer fraud. Ensuring that products correspond accurately to their labeling and contain no undeclared or unauthorized additives is essential to maintaining consumer trust and regulatory compliance.

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Conclusion

Based on the analysis of the quality parameters and technological characteristics of various types of vegetable oils, it can be concluded that strict compliance with the Regulation on Vegetable Oils is crucial for ensuring their quality, nutritional *v*alue, and technological suitability. In the context of the growing demand for high-quality and authentically labeled food products, producers must adhere rigorously to the prescribed standards, while consumers should remain informed about labeling accuracy and the geographical origin of the oils. Sustained quality assurance and transparency throughout the production process are essential for maintaining high standards and fostering consumer trust.

Chromatographic techniques represent a fundamental analytical approach for monitoring oil quality, detecting adulteration, and ensuring conformity with international regulatory requirements. In this regard, gas chromatography with flame ionization detection

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(GC–FID) has been demonstrated as a reliable, cost-effective, and practical method under laboratory conditions for the routine quality control of edible oils.

The results of this study confirm the robustness and reliability of GC–FID for characterizing fatty acid profiles in various edible oils, including olive oils refined sunflower oil (*Zolotaya Semechka* – Russia), palm oil (*Palm Oil* – Malaysia), (*Oleum Viride Belic* – Croatia; *Greta Eleon* – Greece), and unbranded olive oil from a private producer (Albania). The selection of samples, representing diverse geographical origins and processing technologies, enabled a comparative evaluation of authenticity and quality.

The detection of an adulterated olive oil sample underscores the necessity of establishing rigorous quality assurance frameworks that extend beyond analytical verification and encompass full traceability and transparency across the supply chain. These findings reinforce the importance of implementing advanced chromatographic techniques within national quality control systems. Such integration would empower health authorities, producers, and regulatory institutions to more effectively prevent fraud, enhance consumer confidence, and ensure alignment with global standards for food safety and authenticity.

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Резиме

Примена на гасна хроматографија за определување на составот на масните киселини и автентичноста на маслата за јадење

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Клучни зборови: екстра девствено маслиново масло, сончогледово масло, палмино масло, измама, метил естери на масни киселини, гасна хроматографија (GC-FID), оценка на квалитетот

Квалитетот и автентичноста на маслата за јадење претставуваат клучни параметри во прехранбената индустрија, со директно влијание врз здравјето на потрошувачите и економската стабилност на пазарот. Метил-естерите на масни киселини (FAMEs), главните компоненти на маслата за јадење, служат како биохемиски индикатори за оценка на нивното потекло, степенот на преработка и нутритивниот квалитет.

Со зголемената појава на фалсификување на масла — каде високо вредни масла се делумно или целосно заменуваат со поевтини алтернативи без соодветно декларирање — постои растечка потреба за прецизни и сигурни аналитички

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методологии. За справување со овој предизвик, напредните хроматографски техники стануваат клучни алатки за обезбедување на следливост и автентичност на производите.

Техниката на гасна хроматографија со пламенска јонска детекција (GC–FID) претставува една од најефективните техники за идентификација и квантитативно определување на масни киселини. Благодарение на високата селективност, чувствителност и репродуктивност, GC–FID овозможува генерирање на карактеристични хемиски профили за различни видови масла, што го олеснува откривањето на фалсификувани, мешани или погрешно декларирани производи. Како резултат, неговата примена во следење на квалитетот и автентичноста на јадливите масла има критично значење за регулаторните органи, производителите и потрошувачите подеднакво. Целта на ова истражување е да се воспостави и валидира (верифицира) GC–FID методологија за определување на составот на масни киселини во сончогледово, маслиново и палмино масло. Предложениот метод покажува висока аналитичка сигурност и практична применливост под индустриски и лабораториски услови, нудејќи солидна основа за идно стандардизирање во системите за контрола на квалитетот на храната.

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Table 1. Composition of FAME standard

Chain	Compound (CAS#)	% by Weight
C4:0	Methyl butyrate (623-42-7)	4%
C6:0	Methyl caproate (106-70-7)	4%
C8:0	Methyl caprylate (111-11-5)	4%
C10:0	Methyl decanoate (110-42-9)	4%
C11:0	Methyl undecanoate (1731-86-8)	2%
C12:0	Methyl dodecanoate (111-82-0)	4%
C13:0	Methyl tridecanoate (1731-88-0)	2%
C14:0	Methyl myristate (124-10-7)	4%
C14:1 (cis-9)	Methyl myristoleate (56219-06-8)	2%
C15:0	Methyl pentadecanoate (7132-64-1)	2%
C15:1 (cis-10)	Methyl 17eptadecanoate (90176-52-6)	2%
C16:0	Methyl palmitate (112-39-0)	6%
C16:1 (cis-9)	Methyl palmitoleate (1120-25-8)	2%
C17:0	Methyl heptadecanoate (1731-92-6)	2%
C17:1 (cis-10)	Methyl 17eptadecanoate (75190-82-8)	2%
C18:0	Methyl stearate (112-61-8)	4%
C18:1 (trans-9)	Methyl octadecenoate (1937-62-8)	2%
C18:1 (cis-9)	Methyl oleate (112-62-9)	4%
C18:2 (all-trans-9,12)	Methyl linolelaidate (2566-97-4)	2%
C18:2 (all-cis-9,12)	Methyl linoleate (112-63-0)	2%
C18:3 (all-cis-6,9,12)	Methyl gamma-linolenate (16326-32-2)	2%
C18:3 (all-cis-9,12,15)	Methyl linolenate (301-00-8)	2%
C20:0	Methyl arachidate (1120-28-1)	4%
C20:1 (cis-11)	Methyl eicosenoate (2390-09-2)	2%
C20:2 (all-cis-11,14)	Methyl eicosadienoate (2463-02-7)	2%
C20:3 (all-cis-8,11,14)	Methyl eicosatrienoate (21061-10-9)	2%
C20:3 (all-cis-11,14,17)	Methyl eicosatrienoate (55682-88-7)	2%
C20:4 (all-cis-5,8,11,14)	Methyl arachidonate (2566-89-4)	2%
C20:5 (all-cis-5,8,11,14,17)	Methyl eicosapentaenoate (2734-47-6)	2%
C21:0	Methyl heneicosanoate (6064-90-0)	2%
C22:0	Methyl behenate (929-77-1)	4%

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Chain	Compound (CAS#)	% by Weight
C22:1 (cis-13)	Methyl erucate (1120-34-9)	2%
C22:2 (all-cis-13,16)	Methyl docosadienoate (61012-47-3)	2%
C22:6 (all-cis-4,7,10,13,16,19)	Methyl docosahexaenoate (2566-90-7)	2%
C23:0	Methyl tricosanoate (2433-97-8)	2%
C24:0	Methyl lignocerate (2442-49-1)	4%
C24:1 (cis-15)	Methyl nervonate (2733-88-2)	2%

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Table 2. Gas Chromatograph method parameters

Instrument and Parameters	
Instrument Name	Clarus 690
Instrument Type	PerkinElmer AutoSystem GC with built-in autosampler and FID detector
Autosampler method	
Injection Volume	1.0 µL
Carriers parameters	
Carrier	He
Column length	100.00 m
Diameter	250 µm
Split Ratio	100.0 : 1
Detector Parameters	
Detector	FID
Heated Zones	
Injector	CAP
Setpoint	250 °C
Detector	300 °C
Oven Program	
Initial Temp	60°C
Initial Hold	1.00 min
Maximum Temp	240°C
Ramp 1	15.0 0/min to 170°C, hold for 12.00 min
Ramp 2	4.0 0/min to 220°C, hold for 0.00 min
Ramp 3	2.0 0/min to 240°C, hold for 10.00 min
Total Run Time	52.83 min
Equilibration Time	0.5 min

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Table 3. Retention time repeatability for 37 FAMEs mix

Fatty Acid Methyl Ester (FAME)	Average RT (min; n=5)
Methyl Butyrat C4:0	8.9
Methyl Hexanoate C6:0	10.3
Methyl Octanoate C8:0	11.84
Methyl Decanoate C10:0	13.5
Methyl Undecanoate C11:0	14.45
Methyl Laurate C12:0	15.52
Methyl Tridecanoate C13:0	16.84
Methyl Muristate C14:0	18.43
Methyl Muristoleate C14:1n-9	20.21
Methyl Pentadecanoate C15:0	20.49
Methyl 10-Pentadecanoate C15:1n-6	22.49
Methyl Palmitate C16:0	22.79
Methyl Palmitoleate C16:1n-9	24.52
Methyl Heptadecanoate C17:0	25.1
Methyl 10-Heptadecanoate C17:1n-7	26.8
Methyl Stearate C18:0	27.45
Methyl Elaidate 9t-C18:1	28.43
Methyl Oleate C18:1	28.85
Methyl Linoelaidate 9t, 12t-C18:2	30.0
Methyl Linoleate C18:2n-6	30.9
Methyl Arachidate C20:0	31.69
Methyl Gamma Linolenate C18:3n-6	32.3
Methyl 11-Eicosenoate C20:1n-9	32.9
Methyl Linolenate C18:3n-3	33.12
Methyl Heneicosanoate C21:0	33.59
Methyl 11-14 Eicosadienoate C20:2n-6	34.75
Methyl Behenate C22:0	35.37
Methyl Homogamma Linolenate C20:3n-6	36.09
Methyl Eurcate C22:1n-9	36.59
Methyl 11-14-17 Eicosatrienoate C20:3n-3	36.72
Methyl Arahidonate C20:4n-6	37.09
Methyl Tricosanoate C23:0	37.24
Methyl Docosadienoate C22:2n-6	38.39
Methyl Lignocerate C24:0	38.97
Methyl Eicosapentanoate C20:5n-3	39.21
Methyl Nervonate C24:1n-9	40.14
Methyl Docosahexanoate C22:6n-3	44.15

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Table 4. Obtained results of fatty acid analysis for determining the quality of sunflower oil, palm oil, olive oil, and cold-pressed olive oil using the GC method, expressed in %, ND – not detected end permitted minimum (Min) and maximum (Max) concentrations of fatty acids to the Rulebook

	Methyl Palmitate C16:0	Methyl Palmitoleate C16:1	Methyl Stearate C18:0	Methyl Oleate C18:1	Methyl Linoleate C18:2	Methyl Gamma C18:3
Sunflower oil	5.35	ND	2.82	30.72	61.97	ND
Min / Max	5.0 - 7.6	ND	2.7 - 6.5	14.0 - 39.4	48.3 - 74.0	ND
Palm oil	45.57	ND	3.68	40.37	10.03	ND
Min / Max	39.3 -47.5	ND	3.5-6.0	36.0-44.0	9.0-12.0	ND
Olive oil, Croatia	13.74	1.06	2.82	82.68	6.78	1.16
Olive oil, Greece	11.94	0.45	2.2	77.09	7.31	ND
Olive oil, Albania	6.58	ND	2.73	30.35	58.93	ND
Min / Max	up to 20	0.3-3.5	0.5-5.0	55-83	3.5-21	up to 1.5

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