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Review

Is Olive Oil Always the Healthiest Choice? A Comparative Review of Fatty Acid Profiles, Bioactive Compounds, and Evidence-Based Health Effects of Edible Plant Oils

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Abstract: Edible plant oils represent an essential component of human nutrition and are among the most important dietary sources of fatty acids and bioactive compounds. Olive oil, particularly extra virgin olive oil, has long been regarded as the nutritional gold standard due to its favorable monounsaturated fatty acid profile, high polyphenol content, oxidative stability, and extensive clinical evidence supporting its health benefits. However, the increasing availability of alternative plant oils with distinct nutritional characteristics has raised questions regarding whether olive oil can universally be considered the healthiest dietary oil. This review critically compares major edible plant oils, including olive, canola, avocado, flaxseed, camelina, perilla, hempseed, soybean, corn, sunflower, peanut, and algal oils, with respect to their fatty acid composition, bioactive compound profiles, and evidence-based health effects. Particular attention is given to saturated, monounsaturated, and polyunsaturated fatty acids, omega-6/omega-3 balance, polyphenols, tocopherols, phytosterols, carotenoids, and other biologically active constituents. Furthermore, the available evidence concerning cardiovascular health, inflammation, oxidative stress, cognitive function, metabolic disorders, and obesity is evaluated. The findings indicate that although olive oil remains one of the most scientifically supported and nutritionally valuable edible oils, it does not consistently outperform all alternative oils across every health-related parameter. Several oils, particularly flaxseed, camelina, perilla, canola, and algal oils, exhibit distinct advantages regarding omega-3 fatty acid content and fatty acid balance. Overall, current evidence supports a diversified and evidence-based approach to edible oil consumption rather than reliance on a single universally superior oil source.

Keywords: *Olive oil; edible plant oils; fatty acids; omega-3 fatty acids; omega-6 fatty acids; bioactive compounds; polyphenols; cardiovascular health; nutrition; functional foods.*

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1. Introduction

Edible plant oils represent one of the most important components of the human diet, serving not only as a concentrated source of energy but also as a significant supplier of essential fatty acids and numerous bioactive compounds [1]. Over recent decades, growing scientific interest has focused on the relationship between dietary fat quality and human health, leading to increased attention toward the nutritional characteristics of various edible oils [3,4]. The composition of dietary fats has been recognized as a critical determinant of cardiovascular health, metabolic function, inflammatory processes, cognitive performance, and overall well-being. Consequently, the selection of appropriate dietary oil sources has become an important topic in both nutritional science and public health [1-5].

Among all edible plant oils, olive oil has achieved a unique status and is frequently regarded as the healthiest dietary oil available. This perception has largely been driven by extensive scientific evidence supporting the health benefits associated with the Mediterranean diet, in which extra virgin olive oil represents the primary source of dietary fat [9]. Numerous epidemiological studies, clinical trials, and meta-analyses have demonstrated associations between olive oil consumption and reduced risks of cardiovascular disease, hypertension, type 2 diabetes, metabolic syndrome, neurodegenerative disorders, and certain forms of cancer. These beneficial effects have been attributed not only to its favorable fatty acid composition, characterized by a high content of monounsaturated fatty acids, particularly oleic acid, but also to the presence of bioactive compounds such as polyphenols, tocopherols, phytosterols, and squalene [8-14].

Despite its well-established reputation, the growing diversification of edible plant oils available on the global market has raised important questions regarding whether olive oil can universally be considered the optimal dietary choice. Advances in agricultural production, food technology, and nutritional sciences have introduced a variety of alternative plant oils with unique compositional characteristics and potential health-promoting properties. Oils derived from flaxseed, hempseed, camelina, perilla, avocado, rapeseed, and microalgae have attracted increasing scientific attention due to their distinct fatty acid profiles and high concentrations of biologically active compounds. Some of these oils contain substantially greater amounts of omega-3 fatty acids than olive oil, while others provide superior levels of antioxidants, phytosterols, or other functional constituents [1,2,19,22-29].

The health effects of edible oils are influenced by multiple factors beyond their total fat content. The relative proportions of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA), as well as the balance between omega-6 and omega-3 fatty acids, play critical roles in determining their physiological impact. Furthermore, the presence of minor bioactive components contributes significantly to antioxidant capacity, anti-inflammatory activity, lipid metabolism regulation, and cellular protection. Therefore, evaluating the health value of edible oils requires a comprehensive assessment that extends beyond traditional classifications based solely on individual fatty acid groups [3-7,36-40].

In recent years, increasing attention has also been directed toward sustainability considerations related to edible oil production. Environmental concerns, climate change, resource utilization, and the growing demand for sustainable food systems have prompted researchers to evaluate oil sources not only from nutritional and health perspectives but also through ecological and economic lenses. Emerging plant oils and oils derived from microalgae have been proposed as promising alternatives capable of meeting future nutritional demands while reducing environmental burdens associated with conventional food production systems [45-51].

Given the expanding body of scientific literature and the increasing availability of diverse plant-derived oils, there is a need for a comprehensive evaluation of their nutritional characteristics and health implications. While olive oil remains one of the most extensively studied edible oils, evidence suggests that different plant oils may offer specific advantages depending on the health outcome, nutritional objective, and dietary context under consideration [1,2,4].

Therefore, the objective of this review is to critically compare major edible plant oils with respect to their fatty acid composition, bioactive compound content, and evidence-based health effects. Particular emphasis is placed on examining whether olive oil consistently demonstrates superior nutritional and health-promoting properties when compared with other plant-derived oils, including emerging functional oils. By integrating findings from experimental studies, clinical investigations, and recent review literature, this paper aims to provide an updated perspective on the strengths and limitations of different edible plant oils and to contribute to evidence-based dietary recommendations for both consumers and healthcare professionals.

2. Classification of edible plant oils

Edible plant oils constitute a highly diverse group of lipid-rich products obtained from seeds, fruits, nuts, and other plant tissues. They differ considerably in their botanical origin, extraction methods, fatty acid composition, bioactive compound content, oxidative stability, sensory characteristics, and nutritional value. These differences significantly influence their technological applications, shelf life, culinary suitability, and potential health effects. Consequently, the classification of edible plant oils is essential for understanding their nutritional properties and guiding evidence-based dietary recommendations [1-3,15].

Traditionally, edible oils have been classified according to their botanical source, although modern nutritional science increasingly emphasizes classifications based on fatty acid composition and functional properties. From a botanical perspective, plant oils may be derived from fruits, such as olive and avocado oils, or from seeds, including sunflower, soybean, flaxseed, rapeseed, hempseed, sesame, and camelina oils. Each source contributes unique chemical and biological characteristics that determine its nutritional and technological value [1,2,16].

2.1 Traditional Edible Plant Oils

Traditional edible oils have been consumed for centuries and currently dominate global vegetable oil production and consumption. These oils account for the majority of dietary fat intake worldwide and form the foundation of numerous regional dietary patterns [1,15].

Olive Oil

Olive oil is obtained from the fruits of the olive tree (*Olea europaea* L.) and is widely recognized as a key component of the Mediterranean diet. Depending on processing methods, olive oil may be classified as extra virgin, virgin, refined, or pomace oil. Extra virgin olive oil is characterized by minimal processing and retains high concentrations of phenolic compounds, contributing to its antioxidant and anti-inflammatory properties. Its fatty acid profile is dominated by monounsaturated fatty acids, particularly oleic acid, which typically accounts for 55–83% of total fatty acids [8-12,16-18].

Sunflower Oil

Sunflower oil is extracted from the seeds of *Helianthus annuus* L. and is among the most widely consumed vegetable oils globally. Conventional sunflower oil is rich in linoleic acid, an omega-6 polyunsaturated fatty acid, while high-oleic sunflower varieties contain significantly higher concentrations of oleic acid and exhibit improved oxidative stability. Sunflower oil is also recognized as an important dietary source of tocopherols, especially vitamin E [3,32,33].

Soybean Oil

Soybean oil, produced from *Glycine max*, represents one of the largest vegetable oil commodities worldwide. It contains substantial amounts of polyunsaturated fatty acids, including both linoleic acid and α-linolenic acid (ALA). Due to its favorable fatty acid composition and economic accessibility, soybean oil plays an important role in both human nutrition and food processing industries [1-3].

Rapeseed (Canola) Oil

Canola oil is derived from specially developed cultivars of rapeseed (*Brassica napus* L.) characterized by low levels of erucic acid and glucosinolates. It possesses one of the most balanced fatty acid profiles among commonly consumed edible oils, combining relatively low saturated fat content with moderate concentrations of omega-3 fatty acids and a favorable omega-6/omega-3 ratio. As a result, canola oil is frequently recommended in dietary guidelines aimed at reducing cardiovascular disease risk [19,20].

Corn and Peanut Oils

Corn oil and peanut oil remain important dietary oils in many regions. Corn oil is particularly rich in linoleic acid and phytosterols, whereas peanut oil is characterized by a relatively high proportion of monounsaturated fatty acids and favorable thermal stability, making it suitable for high-temperature cooking applications [1,2,30-33].

2.2 Emerging Functional Plant Oils

In recent years, growing consumer interest in functional foods and personalized nutrition has stimulated increased attention toward alternative plant oils possessing unique nutritional and health-promoting properties. These oils are often characterized by exceptionally high concentrations of specific fatty acids, antioxidants, or other bioactive constituents [1,5,22-29].

Flaxseed Oil

Flaxseed oil, obtained from *Linum usitatissimum* L., is among the richest known plant sources of α-linolenic acid (ALA), often containing more than 50% omega-3 fatty acids. Due to its exceptionally high ALA content, flaxseed oil has attracted considerable interest regarding cardiovascular health, inflammation modulation, and metabolic regulation. However, its high degree of unsaturation also makes it highly susceptible to oxidative deterioration [22-24].

Hempseed Oil

Hempseed oil is extracted from the seeds of *Cannabis sativa* L. and possesses a distinctive fatty acid composition characterized by a favorable balance between omega-6 and omega-3 fatty acids. In addition to essential fatty acids, hempseed oil contains phytosterols, tocopherols, and various phenolic compounds that may contribute to its biological activity [25].

Camelina Oil

Camelina oil, derived from *Camelina sativa*, has emerged as a promising functional oil due to its high omega-3 fatty acid content, natural antioxidant compounds, and relatively good oxidative stability compared with other highly unsaturated oils. Its nutritional profile has generated growing scientific interest in both human and animal nutrition [26].

Perilla Oil

Perilla oil, obtained from *Perilla frutescens*, is particularly notable for its exceptionally high concentration of α-linolenic acid, which may exceed 60% of total fatty acids. Traditionally used in several Asian countries, perilla oil has recently gained attention as a potential plant-based alternative for increasing dietary omega-3 intake [27,28].

Avocado Oil

Avocado oil is extracted from the pulp of Persea americana and resembles olive oil in many aspects of its fatty acid composition. It is rich in monounsaturated fatty acids, especially oleic acid, and contains significant amounts of phytosterols, carotenoids, and antioxidant compounds. Its favorable thermal stability also makes it suitable for various culinary applications [29].

Algal Oils

Although less established than conventional plant oils, oils derived from microalgae represent an emerging category of functional lipid sources. Unlike most terrestrial plants, certain microalgal species are capable of synthesizing substantial quantities of long-chain omega-3 fatty acids, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Consequently, algal oils have attracted increasing interest as sustainable alternatives to marine-derived omega-3 supplements [5,43,44].

2.3 Classification Based on Fatty Acid Composition

From a nutritional perspective, edible oils may also be categorized according to their predominant fatty acid groups. Oils such as olive, avocado, and high-oleic sunflower oils are classified as monounsaturated fatty acid-rich oils. In contrast, sunflower, soybean, and corn oils are generally considered polyunsaturated fatty acid-rich oils due to their elevated linoleic acid content. Flaxseed, perilla, camelina, and hempseed oils represent omega-3-enriched oils because of their substantial concentrations of α-linolenic acid [1-6].

This classification is particularly important because fatty acid composition directly influences physiological effects, oxidative stability, and suitability for specific dietary applications. Oils rich in monounsaturated fatty acids generally demonstrate greater resistance to oxidation, whereas highly polyunsaturated oils often provide superior sources of essential fatty acids but may require more careful handling and storage conditions [2,3,34,35].

Overall, the remarkable diversity of edible plant oils highlights the complexity of identifying a universally superior oil. Each oil possesses unique compositional features and potential advantages that may contribute differently to human health [1,2].

3. Fatty acid composition of edible plant oils

The nutritional quality and physiological effects of edible plant oils are largely determined by their fatty acid composition. Fatty acids serve as fundamental structural components of cellular membranes, precursors of numerous signaling molecules, and major sources of dietary energy. Variations in the proportions of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) significantly influence the metabolic, cardiovascular, inflammatory, and oxidative responses associated with oil consumption. Consequently, understanding the fatty acid profiles of edible oils is essential for evaluating their nutritional value and potential health implications [1-4].

Over the past several decades, dietary recommendations have increasingly emphasized the importance of replacing saturated fats with unsaturated fatty acids. Numerous epidemiological studies and clinical trials have demonstrated that diets rich in unsaturated fats are generally associated with improved lipid profiles, reduced cardiovascular risk, and favorable metabolic outcomes. However, not all unsaturated fatty acids exert identical biological effects, and substantial differences exist among plant oils regarding both the quantity and quality of individual fatty acids [36-38].

3.1 Saturated Fatty Acids (SFA)

Saturated fatty acids are characterized by the absence of double bonds within their carbon chains. Although they play important physiological roles in membrane structure and energy metabolism, excessive dietary intake of certain saturated fatty acids has traditionally been associated with elevated low-density lipoprotein (LDL) cholesterol concentrations and increased cardiovascular disease risk [36-38].

Most commonly consumed edible plant oils contain relatively low concentrations of saturated fatty acids compared with animal-derived fats. Olive oil typically contains approximately 10–15% saturated fatty acids, primarily palmitic acid. Similar values are observed in canola oil and flaxseed oil. In contrast, tropical oils such as coconut and palm oil contain substantially higher saturated fat concentrations, although these oils fall outside the primary focus of the present review [2,3].

Among the oils considered in this review, canola oil generally exhibits one of the lowest saturated fat contents, while sunflower, flaxseed, camelina, and hempseed oils also maintain relatively low levels. The reduced proportion of saturated fatty acids contributes to their favorable cardiovascular profiles and aligns with contemporary dietary recommendations promoting unsaturated fat consumption [2,3,19].

3.2 Monounsaturated Fatty Acids (MUFA)

Monounsaturated fatty acids contain a single double bond within their molecular structure. Oleic acid (C18:1 n-9) is the predominant monounsaturated fatty acid found in most edible oils and is widely recognized for its beneficial effects on cardiovascular health, lipid metabolism, and oxidative stability [19,21].

Olive oil is particularly notable for its exceptionally high oleic acid content, which commonly ranges from 55% to more than 80% of total fatty acids depending on cultivar, geographical origin, and processing conditions. This characteristic largely explains the remarkable oxidative stability of olive oil and its central role in the Mediterranean dietary pattern [9,10,16].

Avocado oil displays a similar fatty acid profile and frequently contains comparable concentrations of oleic acid. High-oleic sunflower oil also represents an increasingly important source of monounsaturated fatty acids due to breeding programs aimed at improving oxidative stability and nutritional quality [29].

The cardiovascular benefits associated with MUFA-rich oils include reductions in LDL cholesterol, improvements in endothelial function, and decreased susceptibility of lipoproteins to oxidative modification. These effects have contributed significantly to the widespread perception of olive oil as the benchmark against which other edible oils are frequently compared [19,21,37,38].

3.3 Polyunsaturated Fatty Acids (PUFA)

Polyunsaturated fatty acids contain two or more double bonds and include both omega-6 and omega-3 fatty acids. Because humans lack the enzymatic capacity to synthesize certain polyunsaturated fatty acids, they must be obtained through dietary sources and are therefore considered essential nutrients [4-6,39,40].

Sunflower, soybean, corn, hempseed, flaxseed, camelina, and perilla oils are characterized by relatively high PUFA concentrations. The abundance of polyunsaturated fatty acids contributes to numerous physiological functions, including membrane fluidity, immune regulation, neurological development, and inflammatory signaling pathways [2,3,25,26].

However, the high degree of unsaturation also increases susceptibility to oxidation, particularly during prolonged storage or exposure to elevated temperatures. As a result, oils rich in PUFA often require careful handling and may be less suitable for certain cooking applications compared with MUFA-dominant oils [34,35].

3.4 Omega-3 Fatty Acids

Omega-3 fatty acids have attracted considerable scientific interest due to their well-documented associations with cardiovascular protection, anti-inflammatory activity, neurological function, and metabolic health. Among plant-derived oils, alpha-linolenic acid (ALA; C18:3 n-3) represents the primary omega-3 fatty acid [4-6,39-42].

Flaxseed oil is widely recognized as the richest conventional plant source of ALA, frequently containing more than 50% omega-3 fatty acids. Perilla oil may contain even higher concentrations, while camelina and hempseed oils also provide substantial amounts [22-24,27,28].

Although ALA can be converted into longer-chain omega-3 fatty acids such as EPA and DHA within the human body, the conversion efficiency is generally limited. Consequently, the physiological benefits associated with ALA-rich oils may differ from those observed with direct dietary sources of EPA and DHA [24,41,42].

Recent developments in food biotechnology have increased interest in algal oils because they contain preformed EPA and DHA. Unlike terrestrial plant oils, certain microalgae naturally synthesize these biologically active long-chain omega-3 fatty acids, making algal oils a potentially valuable component of plant-based nutritional strategies [5,43,44].

3.5 Omega-6 Fatty Acids

Linoleic acid (LA; C18:2 n-6) is the principal omega-6 fatty acid present in edible plant oils and is essential for normal growth, development, and cellular function. Sunflower oil, corn oil, and soybean oil are particularly rich sources of linoleic acid [4,6,7].

Historically, increasing dietary omega-6 intake contributed to reductions in saturated fat consumption and improvements in cardiovascular health outcomes. Nevertheless, concerns have emerged regarding the substantial increase in omega-6 fatty acid consumption observed in many industrialized populations [36,38].

While omega-6 fatty acids remain essential nutrients, excessive intake relative to omega-3 fatty acids may influence inflammatory pathways and alter the production of bioactive lipid mediators. Therefore, contemporary nutritional research increasingly emphasizes the importance of evaluating not only absolute fatty acid concentrations but also the balance between omega-6 and omega-3 fatty acids [6,7,39].

3.6 Omega-6/Omega-3 Ratio

The omega-6/omega-3 ratio is frequently regarded as one of the most informative indicators of the nutritional quality of dietary fats. Evolutionary evidence suggests that human diets historically contained omega-6 and omega-3 fatty acids in relatively balanced proportions, whereas modern dietary patterns often exhibit ratios exceeding 15:1 or even 20:1 [6,7].

Substantial variation exists among edible oils regarding this parameter. Conventional sunflower oil may display omega-6/omega-3 ratios exceeding 100:1 due to its minimal omega-3 content. Corn oil and soybean oil also exhibit relatively high ratios, although soybean oil generally contains more ALA than sunflower oil [2,3].

In contrast, flaxseed, camelina, hempseed, and perilla oils possess highly favorable omega-6/omega-3 ratios. Flaxseed and perilla oils frequently contain more omega-3 than omega-6 fatty acids, while hempseed and camelina oils provide ratios considered closer to those recommended for optimal health [22,25-28].

These differences highlight an important limitation in the common perception that olive oil is universally superior. Although olive oil demonstrates numerous advantages due to its high monounsaturated fatty acid content and rich supply of bioactive compounds, it contains relatively modest amounts of omega-3 fatty acids. Consequently, certain alternative plant oils may offer distinct nutritional benefits depending on the specific physiological outcomes being considered [1,2,6,9].

The remarkable diversity of fatty acid profiles among edible plant oils underscores the importance of evaluating multiple nutritional parameters rather than relying on a single indicator of quality (Table 1). While olive oil remains one of the most extensively studied and widely recommended dietary oils, emerging evidence suggests that several alternative plant oils possess unique compositional advantages that may contribute to human health through different biological mechanisms [1-3].

Table 1. Comparative fatty acid composition of major edible plant oils (% of total fatty acids) [1-6,19,22,25-29,43,44].

Oil	SFA (%)	MUFA (%)	PUFA (%)	Omega-3 (%)	Omega-6 (%)	Omega-6/Omega-3 Ratio
Olive oil	14	73	11	0.8	10	12.5:1
Avocado oil	12	70	13	1.0	12	12:1
Canola oil	7	63	28	9	19	2.1:1
Sunflower oil	10	20	66	0.3	65	217:1
Soybean oil	15	24	58	7	51	7.3:1
Corn oil	13	29	55	1	54	54:1
Peanut oil	17	49	32	0.3	31	103:1
Hempseed oil	10	13	75	20	55	2.8:1
Camelina oil	9	34	54	35	19	0.5:1
Flaxseed oil	9	18	72	55	16	0.3:1
Perilla oil	7	16	76	60	14	0.2:1
Algal oil*	6	40	50	35**	10	0.3:1

** Representative values reported for commercially available algal oils; ** Includes EPA and DHA.*

4. Bioactive compounds in plant oils

While fatty acid composition represents a primary determinant of the nutritional value of edible oils, growing evidence indicates that numerous minor bioactive constituents substantially contribute to their biological activity and health-promoting properties. These compounds, often present in relatively small quantities, may exert significant antioxidant, anti-inflammatory, cardioprotective, antimicrobial, and metabolic effects. Consequently, evaluating edible oils solely on the basis of fatty acid profiles may provide an incomplete assessment of their overall nutritional quality [1,11,18,30-33].

The concentration and composition of bioactive compounds vary considerably among plant oils depending on botanical origin, cultivar, environmental conditions, maturity stage, extraction method, refining process, and storage conditions. Generally, minimally processed oils retain higher concentrations of naturally occurring bioactive constituents than highly refined products. Extra virgin olive oil is perhaps the most extensively studied example, although numerous other plant oils also contain biologically active compounds with important physiological functions [1,15,18,34,35].

4.1 Polyphenols

Polyphenols comprise one of the most widely investigated groups of bioactive compounds found in edible oils. These secondary plant metabolites possess potent antioxidant properties and play important roles in reducing oxidative stress and inflammation [11,17,18].

Extra virgin olive oil is particularly rich in phenolic compounds, including hydroxytyrosol, tyrosol, oleuropein derivatives, lignans, and various phenolic acids. These compounds have been associated with reduced lipid oxidation, improved endothelial function, decreased inflammatory biomarker expression, and protection against cardiovascular disease [11,12,17,18].

Numerous clinical studies have demonstrated that the health benefits of olive oil cannot be attributed solely to its high oleic acid content. Instead, many protective effects appear to result from synergistic interactions between monounsaturated fatty acids and polyphenolic compounds. This observation helps explain why extra virgin olive oil often exhibits superior biological activity compared with refined olive oils containing similar fatty acid compositions but substantially lower phenolic concentrations [10,11,18].

Beyond olive oil, polyphenols have also been identified in avocado, sesame, hempseed, flaxseed, camelina, and perilla oils. Although concentrations are generally lower than those observed in extra virgin olive oil, these compounds may nevertheless contribute significantly to antioxidant capacity and health outcomes [1,23,26-29].

4.2 Tocopherols (Vitamin E)

Tocopherols represent a family of fat-soluble compounds collectively recognized as vitamin E. They function as powerful antioxidants by protecting cellular membranes and lipoproteins from oxidative damage [31-33].

Among edible oils, sunflower oil is one of the richest natural sources of tocopherols, particularly α-tocopherol. Soybean, corn, canola, hempseed, and camelina oils also contain substantial amounts of vitamin E compounds, although the relative proportions of α-, β-, γ-, and δ-tocopherols differ considerably among oil types [1,32,33].

The biological significance of tocopherols extends beyond antioxidant protection. Research suggests that vitamin E compounds may contribute to immune function, cardiovascular health, neurological protection, and modulation of inflammatory processes. Furthermore, tocopherols improve oil stability by delaying lipid oxidation and extending shelf life [31,32,34,35].

The high tocopherol content of sunflower oil illustrates an important concept in nutritional evaluation: despite its relatively unfavorable omega-6/omega-3 ratio, sunflower oil provides substantial quantities of vitamin E, demonstrating that individual nutritional characteristics should be interpreted within the broader context of overall composition [32,33].

4.3 Phytosterols

Phytosterols are structurally similar to cholesterol and occur naturally in plant-derived foods, including edible oils. The most abundant phytosterols include β-sitosterol, campesterol, and stigmasterol [30,31].

Extensive scientific evidence indicates that phytosterols reduce intestinal cholesterol absorption and contribute to lowering circulating LDL cholesterol concentrations. Consequently, phytosterol-rich foods and supplements are frequently recommended as components of dietary strategies aimed at cardiovascular disease prevention [30,31].

Canola oil, corn oil, soybean oil, sesame oil, and avocado oil generally contain higher phytosterol concentrations than olive oil. This finding further demonstrates that oils often considered nutritionally superior in one aspect may not necessarily dominate across all nutritional parameters [1,19,20,30].

In addition to cholesterol-lowering effects, phytosterols have been investigated for their potential anti-inflammatory, antioxidant, and anticancer properties, although further research is required to fully elucidate these mechanisms [31].

4.4 Carotenoids

Carotenoids are naturally occurring pigments responsible for the yellow, orange, and red coloration observed in many fruits and vegetables. These compounds possess antioxidant activity and may contribute to visual health, immune function, and cellular protection [1,29].

Among edible oils, avocado oil is particularly notable for its carotenoid content. Certain cold-pressed oils, including unrefined olive oil and some specialty seed oils, may also contain measurable concentrations of carotenoids. The preservation of these compounds depends strongly on processing conditions, as refining procedures frequently result in substantial carotenoid losses [29].

Several carotenoids, including lutein and zeaxanthin, have received considerable scientific attention due to their potential roles in reducing age-related macular degeneration and supporting ocular health [1,29].

4.5 Squalene

Squalene is a naturally occurring triterpene compound that serves as an intermediate in cholesterol biosynthesis. Among edible oils, olive oil represents one of the richest dietary sources of squalene [16-18].

Research has suggested that squalene possesses antioxidant, anti-inflammatory, chemoprotective, and skin-protective properties. Although the precise contribution of squalene to the overall health effects of olive oil remains under investigation, its presence may partially explain some of the unique biological activities associated with olive oil consumption [11,17,18].

Interest in squalene has increased considerably in recent years due to its applications in functional foods, cosmetics, and pharmaceutical formulations [1,17].

4.6 Other Bioactive Constituents

Beyond the major classes discussed above, edible oils contain numerous additional compounds that may influence nutritional quality and biological activity. These include lignans, chlorophyll derivatives, phospholipids, triterpenes, flavonoids, coenzyme Q10, and various volatile compounds [1,18,23,25-28].

Flaxseed oil contains lignans that have been associated with antioxidant activity and potential hormone-modulating effects. Sesame oil contains sesamin and sesamolin, compounds recognized for their antioxidant and anti-inflammatory properties. Hempseed oil provides various phenolic compounds and minor cannabinoids that may contribute to biological activity, although concentrations are generally low in commercially available products [23,25].

Emerging research has also identified numerous bioactive compounds in camelina and perilla oils, supporting growing interest in these oils as functional food ingredients [26-28].

4.7 Comparative Assessment of Bioactive Compound Profiles

When the overall bioactive composition of edible oils is considered, olive oil remains exceptional due to its unique combination of monounsaturated fatty acids, polyphenols, and squalene. However, several other oils demonstrate superiority in specific categories. Sunflower oil provides exceptionally high tocopherol concentrations, canola and corn oils are rich in phytosterols, avocado oil contains substantial carotenoid levels, while flaxseed, camelina, hempseed, and perilla oils offer distinctive profiles of antioxidants and functional phytochemicals [1,11,18].

These observations reinforce the concept that no single edible oil can be considered universally superior across all nutritional dimensions. Rather, different oils provide unique combinations of bioactive compounds that may contribute to health through distinct biological mechanisms [1,2].

Consequently, a comprehensive evaluation of edible oils requires consideration of both fatty acid composition and minor bioactive constituents. Together, these factors shape the physiological responses associated with oil consumption and ultimately determine their overall nutritional and health-promoting potential [1,2,11].

5. Olive oil: Why is it considered the gold standard?

Among all edible plant oils, olive oil has achieved a unique and unparalleled reputation within nutritional science and public health. For several decades, it has been widely regarded as the benchmark against which other dietary oils are evaluated. This status is not merely the result of marketing or cultural tradition but is supported by a substantial body of epidemiological, experimental, and clinical evidence demonstrating its potential health benefits. Nevertheless, understanding why olive oil attained this position is essential before critically assessing whether it can truly be considered the healthiest choice under all circumstances [8-14].

5.1 Historical and Cultural Significance

Olive oil has been consumed for thousands of years throughout the Mediterranean region and has long served as a fundamental component of traditional dietary patterns in countries such as Greece, Italy, Spain, and parts of the Middle East and North Africa. Historically, olive oil was valued not only as a food ingredient but also for medicinal, cosmetic, and religious purposes [14-16].

The exceptional longevity and relatively low incidence of cardiovascular disease observed in certain Mediterranean populations during the twentieth century attracted considerable scientific attention. Early epidemiological investigations suggested that dietary habits, particularly the predominant use of olive oil as the principal source of fat, might contribute significantly to favorable health outcomes. These observations ultimately stimulated decades of research that helped establish olive oil as a central element of healthy dietary recommendations worldwide [8,9,14].

5.2 The Mediterranean Diet Connection

The global reputation of olive oil is closely linked to the scientific success of the Mediterranean diet. Numerous observational studies have demonstrated associations between adherence to Mediterranean dietary patterns and reduced risks of cardiovascular disease, metabolic syndrome, type 2 diabetes, cognitive decline, and all-cause mortality [8,13,14].

Within this dietary model, olive oil serves as the primary source of added fat and contributes substantially to overall energy intake. Consequently, olive oil has often been viewed as one of the principal drivers of the health benefits associated with Mediterranean populations [8,9,14].

However, an important methodological consideration must be acknowledged. Many studies evaluate olive oil consumption within the context of an entire dietary pattern characterized by high fruit and vegetable intake, frequent consumption of legumes, whole grains, nuts, and fish, moderate physical activity, and other lifestyle factors. Therefore, isolating the specific contribution of olive oil from the broader Mediterranean lifestyle remains challenging [14].

Despite this limitation, numerous intervention studies have reported beneficial effects associated with olive oil consumption independently of other dietary components, supporting the view that olive oil itself contributes meaningfully to health promotion [8-13].

5.3 Fatty Acid Composition and Cardiovascular Protection

One of the primary reasons for olive oil's favorable reputation lies in its fatty acid composition. Olive oil is particularly rich in monounsaturated fatty acids, especially oleic acid, which typically constitutes the majority of total fatty acids [9,10,16].

Diets rich in monounsaturated fatty acids have consistently been associated with improvements in cardiovascular risk markers. Research has demonstrated that replacing saturated fats with monounsaturated fats may reduce low-density lipoprotein (LDL) cholesterol concentrations while maintaining or improving high-density lipoprotein (HDL) cholesterol levels. Additional benefits include improved endothelial function, reduced oxidative modification of lipoproteins, and enhanced vascular health [19,21,37,38].

The high oleic acid content of olive oil also contributes to its excellent oxidative stability. Compared with highly polyunsaturated oils, olive oil is generally more resistant to oxidation during storage and culinary use, reducing the formation of potentially harmful oxidation products [10,16,34,35].

These characteristics have positioned olive oil as one of the most widely recommended dietary fats for cardiovascular disease prevention [8-10].

5.4 Polyphenols and Antioxidant Capacity

The health effects of olive oil cannot be fully explained by its fatty acid profile alone. A distinguishing feature of extra virgin olive oil is its exceptionally rich content of phenolic compounds, including hydroxytyrosol, tyrosol, oleuropein derivatives, and numerous other antioxidants [11,17,18].

These compounds have attracted substantial scientific interest due to their ability to reduce oxidative stress and modulate inflammatory pathways. Oxidative stress plays a critical role in the development of cardiovascular disease, cancer, neurodegenerative disorders, and various metabolic conditions. Consequently, the antioxidant properties of olive oil polyphenols have been proposed as important mechanisms underlying its health-promoting effects [11,18,39].

Clinical studies have demonstrated reductions in biomarkers of oxidative damage following consumption of polyphenol-rich olive oils. Furthermore, evidence suggests that olive oil phenolics may improve endothelial function, reduce inflammatory mediator production, and influence gene expression related to metabolic regulation [10-12,18].

The European Food Safety Authority (EFSA) has recognized the role of olive oil polyphenols in protecting blood lipids from oxidative damage, further strengthening the scientific basis for olive oil's favorable reputation [12].

5.5 Evidence from Clinical Trials

Perhaps the strongest support for olive oil originates from controlled clinical investigations. Several large-scale intervention studies have reported beneficial effects associated with regular olive oil consumption [8,9,13,14].

Among these, the PREDIMED study is frequently cited as one of the most influential investigations examining the relationship between Mediterranean dietary patterns and cardiovascular health. The study demonstrated significant reductions in major cardiovascular events among participants following Mediterranean diets supplemented with extra virgin olive oil or nuts compared with control groups receiving low-fat dietary advice [8,9,14].

Additional clinical trials have reported favorable effects on blood pressure regulation, lipid metabolism, inflammatory biomarkers, insulin sensitivity, and endothelial function. Emerging evidence also suggests potential benefits for cognitive health and healthy aging [10,13,14].

Importantly, olive oil is one of the few edible oils for which extensive human intervention data are available, contributing significantly to its status as the nutritional gold standard [8-14].

5.6 Limitations and Common Misconceptions

Despite its numerous advantages, several misconceptions surround olive oil. One of the most common assumptions is that olive oil is universally superior to all other edible oils across every nutritional criterion. However, scientific evidence does not fully support this conclusion [1,2,8].

While olive oil excels in monounsaturated fatty acid content, oxidative stability, polyphenol concentration, and clinical evidence, it is not the richest source of omega-3 fatty acids, phytosterols, tocopherols, or several other bioactive compounds. For example, flaxseed, perilla, and camelina oils provide substantially higher levels of alpha-linolenic acid, while sunflower oil contains greater concentrations of vitamin E and certain seed oils may offer superior phytosterol content [1-3,22,26-29,32].

Another misconception involves the assumption that all olive oils possess identical nutritional value. In reality, significant differences exist between extra virgin, virgin, refined, and pomace olive oils. The refining process may substantially reduce concentrations of phenolic compounds and other biologically active constituents, potentially diminishing some health benefits [11,16,18].

Furthermore, although olive oil is often portrayed as the healthiest cooking oil, suitability depends on the intended culinary application. Factors such as smoke point, thermal stability, fatty acid composition, and cooking duration may influence the performance of different oils under specific conditions [34,35].

5.7 Is Olive Oil the Healthiest Oil?

Based on current scientific evidence, olive oil undoubtedly ranks among the healthiest edible oils available and remains one of the most extensively studied dietary fat sources worldwide. Its unique combination of monounsaturated fatty acids, polyphenols, oxidative stability, and strong clinical support distinguishes it from many competing oils [8-14].

However, the question of whether olive oil is universally the healthiest edible oil remains more complex than commonly assumed. Different oils possess distinct nutritional strengths and may provide specific advantages depending on the health outcome being considered. Consequently, evaluating edible oils requires a broader perspective that considers multiple nutritional parameters rather than relying on a single measure of quality [1-6,19,22-29].

The following section therefore examines the evidence-based health effects of major edible plant oils in greater detail and explores whether certain alternatives may outperform olive oil in specific physiological and clinical contexts [1,2].

6. Comparative health effects of edible plant oils

The health effects of edible plant oils are influenced by a complex interplay between fatty acid composition, bioactive compound content, dietary context, genetic factors, and lifestyle characteristics. While olive oil has traditionally been regarded as the reference standard for healthy dietary fats, accumulating evidence suggests that several alternative plant oils may provide comparable or even superior benefits in specific physiological and clinical settings [1-5,36-40].

Importantly, no single oil consistently demonstrates superiority across all health outcomes. Instead, different oils appear to exert distinct biological effects through diverse mechanisms involving lipid metabolism, inflammation, oxidative stress, endothelial function, gut microbiota interactions, and cellular signaling pathways. Consequently, evaluating the health value of edible oils requires consideration of multiple outcomes rather than reliance on a single health indicator [1,2,19,22,25-29].

6.1 Cardiovascular Health

Cardiovascular disease remains the leading cause of mortality worldwide, making cardiovascular protection one of the most extensively studied aspects of edible oil consumption [36-38].

Olive oil possesses perhaps the strongest clinical evidence supporting cardiovascular benefits. Numerous observational studies and randomized controlled trials have associated regular olive oil consumption with reduced risks of coronary heart disease, stroke, hypertension, and cardiovascular mortality. These effects have largely been attributed to its high oleic acid content and abundance of antioxidant polyphenols [8-14].

However, several alternative plant oils have also demonstrated favorable cardiovascular effects. Canola oil, characterized by a low saturated fat content and a balanced omega-6/omega-3 ratio, has consistently been associated with improvements in blood lipid profiles and reductions in cardiovascular risk markers. Flaxseed oil has shown potential benefits through its exceptionally high alpha-linolenic acid content, which may contribute to reductions in blood pressure, vascular inflammation, and arterial stiffness [19,20,22,26].

Emerging evidence suggests that algal oils containing preformed EPA and DHA may provide particularly strong cardioprotective effects, especially among individuals with limited fish consumption. Consequently, while olive oil remains one of the best-supported options for cardiovascular health, it cannot be considered the sole beneficial dietary oil [5,24,39-44].

6.2 Lipid Metabolism and Cholesterol Regulation

The ability of dietary oils to influence lipid metabolism is a major determinant of their health value. Numerous studies have demonstrated that replacing saturated fats with unsaturated plant oils generally improves serum lipid profiles [30,36-38].

Olive oil consistently promotes favorable changes in LDL and HDL cholesterol concentrations. Similar effects have been observed with canola oil and avocado oil due to their high monounsaturated fatty acid content. In contrast, phytosterol-rich oils such as corn oil and canola oil may provide additional cholesterol-lowering effects by reducing intestinal cholesterol absorption [9,10,19-21,29,30].

Several intervention studies have reported that canola oil may reduce LDL cholesterol concentrations to a similar or even greater extent than olive oil under certain dietary conditions. This observation highlights the importance of considering multiple nutritional mechanisms rather than focusing exclusively on olive oil [19,20].

Overall, evidence suggests that numerous plant oils can effectively support healthy lipid metabolism when incorporated into balanced dietary patterns [36-38].

6.3 Inflammation

Chronic low-grade inflammation is increasingly recognized as a key contributor to cardiovascular disease, obesity, diabetes, neurodegeneration, and numerous other chronic disorders [39,40].

Extra virgin olive oil demonstrates substantial anti-inflammatory activity due to its unique combination of oleic acid and phenolic compounds. Several olive oil polyphenols have been shown to influence inflammatory pathways, including nuclear factor kappa B (NF-κB) signaling and cytokine production [10,11,18,39].

However, oils rich in omega-3 fatty acids may offer distinct anti-inflammatory advantages. Flaxseed, camelina, hempseed, and perilla oils provide significant quantities of alpha-linolenic acid, which may contribute to the regulation of inflammatory mediators. Furthermore, algal oils supplying EPA and DHA may exert even stronger anti-inflammatory effects because these long-chain omega-3 fatty acids directly participate in the synthesis of specialized pro-resolving mediators [22,26-28,39,40].

Consequently, while olive oil remains highly effective for reducing inflammation, omega-3-rich oils may provide complementary or superior benefits in specific inflammatory conditions [39,40].

6.4 Oxidative Stress

Oxidative stress results from an imbalance between reactive oxygen species production and antioxidant defense mechanisms and is implicated in aging and numerous chronic diseases [11,34,35].

Among edible oils, extra virgin olive oil is particularly notable for its high antioxidant capacity due to its phenolic content. These compounds contribute significantly to the protection of lipids, proteins, and cellular structures from oxidative damage [11,17,18].

Sunflower oil, despite criticism regarding its omega-6 content, represents one of the richest dietary sources of vitamin E, a potent lipid-soluble antioxidant. Similarly, camelina, hempseed, avocado, and sesame oils contain various antioxidant compounds that may contribute to oxidative stress reduction [31-33].

The effectiveness of an oil in combating oxidative stress therefore depends not only on fatty acid composition but also on its complete profile of antioxidant constituents [1,34,35].

6.5 Cognitive Function and Brain Health

Growing evidence suggests that dietary fatty acids influence brain structure, neurotransmission, neuroinflammation, and cognitive performance throughout the lifespan [5,39-44].

Olive oil has been associated with improved cognitive outcomes within Mediterranean dietary interventions, including slower cognitive decline and reduced risk of neurodegenerative disorders. These effects may be mediated through antioxidant and anti-inflammatory mechanisms [8,13,14].

Nevertheless, omega-3 fatty acids play particularly important roles in neurological function. Since flaxseed, camelina, perilla, and algal oils provide substantially greater omega-3 concentrations than olive oil, they may offer unique advantages for supporting brain health. In particular, algal oils containing DHA represent a direct dietary source of one of the most important structural fatty acids in neuronal membranes [5,24,40-44].

Future research will likely further clarify the relative contributions of olive oil polyphenols and omega-3-rich oils to long-term cognitive health [5,11,24].

6.6 Metabolic Syndrome and Type 2 Diabetes

Metabolic syndrome and type 2 diabetes are major global health challenges characterized by insulin resistance, dyslipidemia, hypertension, and chronic inflammation [13,38].

Several studies have demonstrated improvements in insulin sensitivity and glycemic control following dietary interventions incorporating olive oil. The Mediterranean diet, rich in olive oil, remains one of the most extensively supported dietary strategies for diabetes prevention and management [13,14].

Canola oil has also demonstrated favorable effects on glycemic control, potentially due to its balanced fatty acid composition. Meanwhile, omega-3-rich oils may improve certain aspects of metabolic function through anti-inflammatory mechanisms [19,20].

Current evidence suggests that replacing saturated fats with unsaturated plant oils generally improves metabolic health, although the magnitude of benefits may differ among oil types and populations [36-38].

6.7 Obesity and Weight Management

The relationship between edible oils and body weight is frequently misunderstood. Although all oils are energy-dense foods, their physiological effects may differ considerably [7,14].

Contrary to popular belief, moderate consumption of olive oil has not been associated with increased obesity risk when incorporated into balanced dietary patterns. Several studies have even reported favorable effects on satiety and body composition [8,13,14].

Similar observations have been reported for canola, avocado, and omega-3-rich oils. Some evidence suggests that omega-3 fatty acids may influence adipocyte metabolism, lipid oxidation, and appetite regulation, although findings remain somewhat inconsistent [19,20,22,29,39].

Overall, available evidence indicates that the quality of dietary fats may be more important than absolute fat intake alone in determining long-term weight-related outcomes [36-38].

6.8 Overall Comparative Evaluation

When all major health outcomes are considered collectively, olive oil emerges as one of the most comprehensively supported edible oils due to its combination of favorable fatty acid composition, bioactive compounds, oxidative stability, and extensive clinical evidence [1,8-14].

However, alternative plant oils clearly demonstrate important advantages in specific nutritional domains. Flaxseed, camelina, perilla, and algal oils provide substantially greater omega-3 concentrations; sunflower oil offers exceptional vitamin E content; canola oil exhibits one of the most balanced fatty acid profiles; and avocado oil combines high monounsaturated fat levels with valuable antioxidant compounds [1,19,22,26-29,32,43].

These findings indicate that the concept of a universally superior edible oil may be overly simplistic. Rather than identifying a single "best" oil, contemporary evidence increasingly supports the strategic use of multiple plant oils to maximize nutritional diversity and health benefits (Figure 1). Olive oil undoubtedly remains among the healthiest edible oils available, yet several alternative plant oils may outperform it in specific nutritional and physiological contexts. Understanding these differences is essential for developing evidence-based dietary recommendations tailored to individual health goals and nutritional needs [1,2,5].

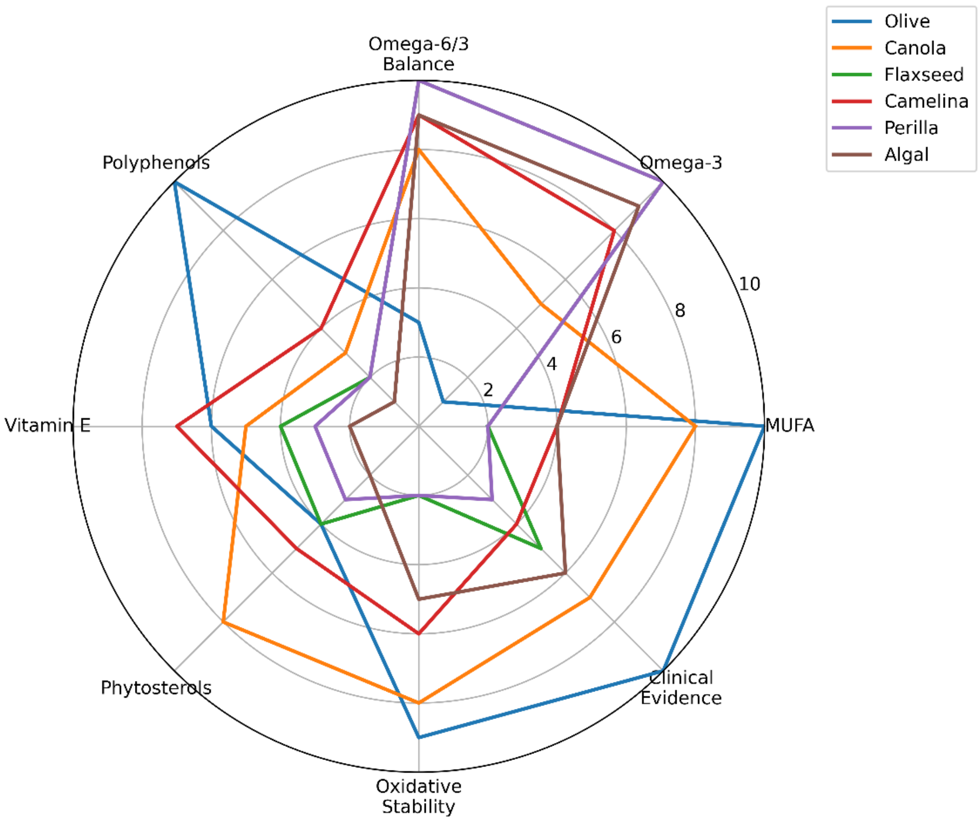

Figure 1. Comparative omega-6/omega-3 ratio of major edible plant oils [1-7,19,22,25-29,43,44].

Figure 1 illustrates the considerable variation in omega-6/omega-3 ratios among major edible plant oils. While olive oil is frequently regarded as one of the healthiest dietary oils, its omega-6/omega-3 ratio is considerably higher than that observed in flaxseed, perilla, camelina, hempseed, canola, and algal oils. These findings highlight an important nutritional limitation of olive oil and demonstrate that certain alternative plant oils may provide more favorable essential fatty acid balances. Nevertheless, omega-6/omega-3 ratio represents only one aspect of oil quality and should be interpreted together with fatty acid composition, bioactive compounds, oxidative stability, and clinical evidence [2-7,22,25-29,43,44].

7. Can other plant oils outperform olive oil?

The widespread perception that olive oil represents the healthiest edible oil available is supported by extensive scientific evidence. Its favorable fatty acid composition, exceptional polyphenol content, oxidative stability, and strong clinical support have firmly established its position within nutritional science. Nevertheless, the question remains whether olive oil consistently outperforms all other plant oils across every nutritional and health-related parameter [8-14].

The evidence reviewed throughout this paper suggests that such a conclusion would be overly simplistic. While olive oil undoubtedly excels in several important categories, numerous alternative plant oils demonstrate advantages in specific nutritional domains. Therefore, rather than identifying a single universally superior oil, contemporary nutritional science increasingly recognizes that different oils may be optimal for different physiological objectives and health outcomes [1,2,19,22,25-29].

7.1 Olive Oil versus Flaxseed Oil

Flaxseed oil represents one of the most frequently discussed alternatives to olive oil due to its exceptionally high alpha-linolenic acid (ALA) content. Whereas olive oil contains relatively small amounts of omega-3 fatty acids, flaxseed oil is among the richest plant-derived sources of ALA available [22-24].

This compositional difference may have important physiological implications. Omega-3 fatty acids are involved in inflammation regulation, cardiovascular protection, neuronal function, and metabolic homeostasis. Consequently, flaxseed oil may provide advantages in situations where increasing omega-3 intake is a primary nutritional objective [4-6,39-42].

However, flaxseed oil also exhibits limitations. Its extremely high degree of unsaturation contributes to poor oxidative stability, reducing its suitability for cooking applications and increasing susceptibility to lipid oxidation during storage. Furthermore, unlike olive oil, flaxseed oil contains relatively limited clinical evidence supporting long-term health outcomes [34,35].

Thus, flaxseed oil may outperform olive oil in terms of omega-3 delivery but not necessarily regarding stability, culinary versatility, or clinical validation [22-24].

7.2 Olive Oil versus Canola Oil

Canola oil possesses one of the most balanced fatty acid profiles among commonly consumed edible oils. It combines low saturated fat content, high monounsaturated fatty acid concentrations, moderate omega-3 levels, and a favorable omega-6/omega-3 ratio [19,20].

Several intervention studies have reported cardiovascular and lipid-lowering effects comparable to those observed with olive oil consumption. In addition, canola oil generally contains higher phytosterol concentrations than olive oil, potentially enhancing cholesterol-lowering effects [19,20,37,38].

Despite these advantages, canola oil contains substantially lower concentrations of phenolic compounds and lacks the extensive body of clinical evidence associated with olive oil. Consequently, canola oil may rival olive oil in terms of fatty acid balance and cardiovascular outcomes but cannot yet match its overall scientific support [11,18,19,20].

7.3 Olive Oil versus Camelina Oil

Camelina oil has emerged as one of the most promising functional oils in recent years. Its unique composition combines relatively high omega-3 fatty acid concentrations with better oxidative stability than many other highly unsaturated oils [26].

Compared with olive oil, camelina oil offers a substantially more favorable omega-6/omega-3 ratio and higher levels of alpha-linolenic acid. These characteristics may provide advantages for inflammation control and overall fatty acid balance [26].

Additionally, camelina oil contains significant concentrations of tocopherols and other antioxidant compounds that contribute to its stability. Nevertheless, research on camelina oil remains limited compared with olive oil, and large-scale clinical investigations are still relatively scarce [26,31,32].

Current evidence suggests that camelina oil may represent one of the strongest competitors to olive oil from a nutritional perspective, particularly when omega-3 intake is emphasized [26].

7.4 Olive Oil versus Perilla Oil

Perilla oil is notable for possessing one of the highest alpha-linolenic acid concentrations among edible plant oils. In many cases, more than half of its fatty acid content consists of omega-3 fatty acids [27,28].

This exceptional composition results in an omega-6/omega-3 ratio that is substantially more favorable than that of olive oil. Consequently, perilla oil may offer important benefits for improving dietary fatty acid balance and reducing excessive omega-6 intake common in many contemporary diets [27,28].

However, similar to flaxseed oil, perilla oil suffers from limited oxidative stability and comparatively modest clinical evidence. Therefore, while it may outperform olive oil regarding omega-3 nutrition, its overall practical and scientific profile remains less comprehensive [27,28,34,35].

7.5 Olive Oil versus Avocado Oil

Among all edible plant oils, avocado oil most closely resembles olive oil in terms of fatty acid composition. Both oils are rich in oleic acid and demonstrate favorable oxidative stability [29].

Avocado oil additionally provides carotenoids, phytosterols, and other bioactive compounds that may contribute to cardiovascular and metabolic health. Its high smoke point and excellent thermal stability make it particularly attractive for culinary applications involving elevated temperatures [29,30,31].

Despite these similarities, olive oil continues to possess stronger clinical support and substantially higher concentrations of phenolic compounds, particularly in extra virgin varieties. Consequently, avocado oil may serve as an excellent alternative to olive oil but cannot currently be considered clearly superior [8-11,18,29].

7.6 Olive Oil versus Algal Oil

Perhaps the most interesting comparison involves algal oils. Unlike conventional terrestrial plant oils, certain microalgae synthesize long-chain omega-3 fatty acids such as EPA and DHA [5,43,44].

Because EPA and DHA are directly utilized by the human body, algal oils circumvent the limited conversion efficiency associated with alpha-linolenic acid from plant sources. As a result, algal oils may provide unique benefits for cardiovascular function, neurodevelopment, cognitive health, and inflammation regulation [24,40-44].

From an omega-3 perspective, algal oils clearly outperform olive oil. However, they generally contain lower concentrations of polyphenols and are not typically used as primary culinary oils. Consequently, algal oils should be viewed as complementary rather than direct replacements for olive oil [5,43,44].

7.7 Is There a Single Best Oil?

The comparisons presented above demonstrate that no edible plant oil dominates across all nutritional criteria. Olive oil remains exceptional due to its combination of monounsaturated fatty acids, antioxidant polyphenols, oxidative stability, and extensive clinical support. Nevertheless, alternative oils clearly possess specific advantages [1,2].

Flaxseed, perilla, camelina, and algal oils outperform olive oil regarding omega-3 fatty acid provision. Canola oil exhibits one of the most balanced fatty acid profiles among commonly consumed oils. Avocado oil provides comparable monounsaturated fat levels together with excellent thermal stability [1,22,26-29,43,44].

These findings challenge the widespread assumption that a single edible oil can be considered universally superior. Instead, evidence increasingly supports a more nuanced perspective in which different oils contribute distinct nutritional strengths [1,2,5].

7.8 Toward a Diversified Oil Strategy

Rather than promoting exclusive reliance on a single oil source, contemporary nutritional evidence supports dietary diversity in edible oil consumption. Combining oils with complementary characteristics may maximize nutritional benefits while minimizing potential limitations associated with any individual oil [1,2,5,56,57].

For example, olive oil may serve as the primary source of monounsaturated fats and polyphenols, whereas flaxseed, camelina, perilla, or algal oils may be incorporated to enhance omega-3 intake. Such an approach aligns with modern concepts of personalized nutrition and recognizes the complexity of human dietary requirements [8-11,22,26-28,43,44].

Therefore, the central question posed by this review can be answered as follows: olive oil remains one of the healthiest edible plant oils available, but it is not universally superior in every nutritional category. Several alternative plant oils outperform olive oil in specific domains, particularly regarding omega-3 fatty acid provision and fatty acid balance. Consequently, the healthiest dietary strategy may involve informed selection and combination of multiple high-quality plant oils rather than exclusive dependence on a single oil source [1,2].

8. Sustainability and future perspectives

The global demand for edible oils has increased substantially over recent decades due to population growth, urbanization, changing dietary habits, and expanding industrial applications. As a result, the evaluation of edible oils is no longer limited to their nutritional quality and health effects. Increasing attention is now directed toward sustainability, environmental impact, resource efficiency, and the ability of oil production systems to meet future food security challenges. Consequently, future recommendations regarding edible oil consumption will likely be influenced not only by health considerations but also by ecological, economic, and social factors [45-49].

8.1 Sustainability Challenges in Edible Oil Production

The production of edible oils requires significant inputs of land, water, energy, fertilizers, and other agricultural resources. The environmental footprint associated with oil crop cultivation varies considerably among plant species and production systems [45-48].

Conventional oilseed crops such as soybean, sunflower, rapeseed, and corn occupy extensive agricultural areas worldwide and contribute significantly to global vegetable oil supplies. However, increasing demand for these oils may intensify pressure on agricultural land, biodiversity, and natural ecosystems. Climate change, soil degradation, water scarcity, and increasing competition between food, feed, and biofuel production further complicate the sustainability of future oil production systems [45-49].

In addition, environmental concerns associated with agricultural intensification have stimulated interest in alternative crops capable of providing high-quality oils while reducing resource requirements and environmental impacts [47,48,54].

8.2 Climate Change and Future Oil Crop Production

Climate change is expected to influence both the quantity and quality of edible oil production worldwide. Rising temperatures, altered precipitation patterns, increased frequency of drought events, and extreme weather conditions may significantly affect crop yields and oil composition [50-52].

Several studies have demonstrated that environmental stressors can alter fatty acid synthesis pathways, leading to changes in oil quality. For example, temperature fluctuations may influence the proportions of saturated and unsaturated fatty acids, while water stress can affect oil yield and oxidative stability [50-52].

These challenges highlight the importance of developing resilient oil crops capable of maintaining productivity and nutritional quality under changing environmental conditions. Future breeding programs will likely focus on improving climate adaptability, resource-use efficiency, disease resistance, and nutritional characteristics simultaneously [50-54].

8.3 Emerging Oil Crops and Functional Oils

Growing scientific interest has focused on several underutilized oil crops possessing favorable nutritional profiles and promising agronomic characteristics [25-28,53,54].

Camelina (Camelina sativa) has attracted considerable attention due to its relatively low production requirements, tolerance to adverse environmental conditions, and high omega-3 fatty acid content. Similarly, hemp (Cannabis sativa) has emerged as a valuable oilseed crop because of its balanced fatty acid profile and potential sustainability advantages [25,26,53].

Perilla, chia, and other omega-3-rich oilseed crops have also gained interest as potential alternatives capable of diversifying edible oil production while improving dietary fatty acid intake [27,28,54].

The increasing cultivation of these crops may contribute to both nutritional diversity and agricultural sustainability, particularly within production systems seeking alternatives to conventional oilseed monocultures [45-48,53,54].

8.4 Microalgae as a Future Source of Edible Oils

Among emerging oil sources, microalgae represent one of the most promising technological innovations in the field of lipid production. Unlike traditional oil crops, microalgae can be cultivated on non-arable land and may utilize saline water, wastewater, or industrial carbon dioxide streams [5,43-45].

Perhaps most importantly, certain microalgal species naturally synthesize substantial quantities of long-chain omega-3 fatty acids, including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These fatty acids are traditionally obtained from marine fish, creating concerns regarding overfishing and marine ecosystem sustainability [5,43,44].

Algal oils therefore offer a potentially sustainable and vegetarian-friendly alternative capable of supplying EPA and DHA without dependence on marine resources. Although production costs remain relatively high, ongoing technological advances are expected to improve economic feasibility and expand commercial applications [5,24,43,44].

Many experts consider algal oils among the most promising candidates for future functional foods and personalized nutrition strategies [43,44,56,57].

8.5 Precision Agriculture and Digital Technologies

Technological innovation is increasingly transforming oil crop production through the implementation of precision agriculture, artificial intelligence, remote sensing, robotics, and advanced data analytics [50,55].

Precision agriculture technologies enable producers to optimize fertilizer application, irrigation management, pest control, and harvesting operations while minimizing environmental impacts. These approaches improve resource-use efficiency and may contribute to both economic and environmental sustainability [50,55].

Furthermore, advances in plant phenotyping, genomics, and digital breeding technologies are accelerating the development of improved oilseed cultivars with enhanced nutritional quality and environmental resilience [50,55].

As digital agriculture continues to evolve, the integration of technological innovation with sustainable oil production will likely become an increasingly important research area [45,55].

8.6 Personalized Nutrition and Functional Oil Selection

One of the most significant developments in contemporary nutritional science is the shift toward personalized nutrition. Rather than applying universal dietary recommendations, personalized approaches seek to account for individual genetic, metabolic, physiological, and lifestyle characteristics [56,57].

Within this framework, the concept of a single universally optimal edible oil becomes increasingly difficult to justify. Individuals with different health conditions and nutritional goals may benefit from different oil choices [56,57].

For example, individuals seeking increased omega-3 intake may benefit from flaxseed, camelina, perilla, or algal oils, whereas those prioritizing oxidative stability and cardiovascular protection may preferentially select olive or avocado oils. Similarly, individuals requiring cholesterol management may benefit from oils rich in phytosterols [1,5,22,26-29,43,44,56].

Future dietary recommendations may therefore emphasize strategic combinations of oils rather than exclusive reliance on a single source of dietary fat [56,57].

8.7 Future Research Directions

Although substantial progress has been made in understanding the nutritional properties and health effects of edible oils, several important research gaps remain [1,2,56,57].

Future investigations should prioritize:

- Long-term randomized clinical trials comparing different edible oils directly.
- Standardization of methods used to evaluate oil quality and health outcomes.
- Better characterization of bioactive compounds in emerging oils.
- Assessment of synergistic interactions between fatty acids and minor bioactive constituents.
- Evaluation of sustainability indicators alongside nutritional outcomes.
- Development of integrated approaches linking nutrition, environmental impact, and food system resilience.

Particular attention should be devoted to emerging oils such as camelina, hempseed, perilla, and algal oils, which currently possess promising nutritional profiles but substantially smaller clinical evidence bases than olive oil [25-29,43,44,56,57].

8.8 Future Perspectives

The future of edible oil research is likely to extend beyond the traditional question of identifying the single healthiest oil. Instead, increasing emphasis will be placed on optimizing oil selection according to individual health objectives, environmental sustainability, and technological innovation [1,2,56,57].

Olive oil will likely continue to occupy a central position within healthy dietary patterns due to its strong scientific foundation and established health benefits. Nevertheless, growing evidence suggests that emerging oils rich in omega-3 fatty acids and novel bioactive compounds may play increasingly important roles in future food systems [8-14].

Advances in biotechnology, precision agriculture, plant breeding, and microalgal cultivation are expected to expand the diversity of available oil sources and create new opportunities for improving both human health and environmental sustainability [43-45,50,55].

Consequently, future nutritional strategies may move away from the concept of a single superior edible oil and instead embrace a diversified approach that integrates multiple high-quality plant oils according to nutritional needs, culinary applications, and sustainability considerations [1,2,56,57].

9. Conclusions

The present review examined the fatty acid composition, bioactive compound profiles, and evidence-based health effects of major edible plant oils with the aim of addressing a widely debated question: Is olive oil always the healthiest choice?

The available scientific evidence confirms that olive oil, particularly extra virgin olive oil, remains one of the most nutritionally valuable and clinically supported edible oils currently available. Its favorable monounsaturated fatty acid profile, high concentration of phenolic compounds, excellent oxidative stability, and extensive body of epidemiological and clinical evidence collectively justify its reputation as a benchmark dietary oil. The health benefits associated with olive oil consumption include improved cardiovascular health, reduced oxidative stress, lower inflammation, favorable lipid metabolism, and potential protection against several chronic diseases.

However, the findings of this review also demonstrate that olive oil is not universally superior across all nutritional and physiological parameters. Several alternative plant oils exhibit advantages in specific categories. Flaxseed, perilla, camelina, and algal oils provide substantially greater omega-3 fatty acid concentrations. Canola oil offers one of the most balanced fatty acid profiles among commonly consumed oils, while avocado oil combines high monounsaturated fat content with excellent thermal stability and valuable antioxidant compounds. These observations challenge the common misconception that a single edible oil can be considered optimal for every nutritional objective.

When all evaluated parameters are considered collectively, including fatty acid composition, omega-6/omega-3 balance, bioactive compounds, oxidative stability, cardiovascular effects, clinical evidence, and overall nutritional quality, the reviewed oils may be broadly ranked as follows:

1. Extra virgin olive oil
2. Canola oil
3. Camelina oil
4. Avocado oil
5. Flaxseed oil
6. Perilla oil
7. Hempseed oil
8. Algal oil
9. Soybean oil
10. Corn oil
11. Peanut oil
12. Sunflower oil

It should be emphasized that this ranking reflects an integrated assessment of currently available evidence rather than absolute superiority under all circumstances. Individual oils may outperform higher-ranked oils for specific nutritional goals, health conditions, or dietary requirements.

Overall, the evidence supports a shift away from the concept of a single "healthiest" edible oil toward a more diversified and evidence-based approach to dietary fat consumption. Future nutritional recommendations should encourage the strategic use of complementary plant oils according to their unique compositional characteristics, health benefits, culinary applications, and sustainability profiles.

In conclusion, olive oil remains one of the healthiest edible oils available and continues to represent the nutritional gold standard. Nevertheless, it should no longer be viewed as the only superior choice. Emerging oils such as camelina, flaxseed, perilla, and algal oils offer unique nutritional advantages that may contribute significantly to future dietary strategies aimed at optimizing human health and sustainability.

Conflicts of Interest: The authors declare no conflicts of interest.

Declaration of Generative AI Use: The authors declare that no generative AI tools were used in the preparation of this manuscript.

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