Literature Review

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Balancing risks and benefits: a review of palm oil consumption and cardiovascular health outcomes

Abstract

Palm oil is among the most widely consumed edible oils worldwide, yet its cardiovascular health implications remain highly debated due to its saturated fat content and diverse processing methods. This study aims to systematically evaluate the scientific evidence on the relationship between dietary palm oil consumption and cardiovascular health, with a focus on lipid metabolism, inflammatory responses, and population-level disease risk. This research adopts a qualitative Systematic Literature Review (SLR) approach, structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Peer-reviewed articles were exclusively sourced from the ScienceDirect database, published between 2021 and 2025. A total of 29 studies were selected through a rigorous four-stage process: identification, screening, eligibility, and inclusion. The collected data were analyzed thematically and interpreted comparatively to synthesize recurring patterns and divergences across studies. The findings reveal that the health outcomes of palm oil consumption are highly context-dependent. Moderate intake of unrefined red palm oil may confer neutral or even favorable effects on lipid profiles and inflammatory markers, largely attributed to its tocotrienol content. In contrast, excessive intake of refined palm oil is associated with increased LDL levels and pro-inflammatory activity. These outcomes vary based on dosage, oil processing, and dietary substitution patterns. In conclusion, palm oil's cardiovascular impact is complex and multifaceted. Future research should employ standardized longitudinal designs to better elucidate long-term health effects within real-world dietary contexts.

Keywords: palm oil, cardiovascular health, lipid metabolism, inflammation, systematic review

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Introduction

Cardiovascular disease (CVD) remains the foremost cause of mortality worldwide, claiming approximately 17.9 million lives annually and accounting for nearly 32% of all global deaths, as reported by the World Health Organization.[1] The global burden of CVD is projected to rise, particularly in low- and middle-income countries (LMICs), driven by urbanization, sedentary lifestyles, and nutritional transitions that favor energy-dense, nutrient-poor diets.[2] Among modifiable lifestyle factors, dietary fat intake has garnered considerable attention due to its direct impact on serum lipid levels, systemic inflammation, and vascular function. Within this context, the type and source of dietary fat are recognized as critical determinants of cardiovascular risk.[3]

Palm oil has emerged as a central focus of this discourse. Derived from the mesocarp of the oil palm fruit (*Elaeis guineensis*), palm oil is currently the most widely produced and consumed vegetable oil globally, constituting over 35% of global vegetable oil output and present in nearly 50% of packaged food products.[4] Its widespread use spans household cooking, industrial food processing, cosmetics, and biofuel production. Economically, palm oil is a cornerstone of agricultural income for countries such as Indonesia and Malaysia, which together account for over 80% of global supply.[5] However, from a nutritional and biomedical standpoint, palm oil's high saturated fatty acid (SFA) content, approximately 50%, primarily in the form of palmitic acid, has raised significant health concerns.[6]

The nutritional composition of palm oil is complex. In addition to saturated fats, it contains monounsaturated (39%) and polyunsaturated fatty acids (11%), as well as minor components like tocopherols, tocotrienols, phytosterols, and carotenoids.[7] These compounds have demonstrated potential antioxidant, anti-inflammatory, and lipid-modulating effects. Notably, red palm oil (RPO), a minimally processed variant, retains higher concentrations of these bioactive compounds than refined palm olein, which is commonly used in frying and food manufacturing.[8] The processing method, whether physical or chemical, can significantly alter palm oil's chemical profile and, consequently, its physiological impact.[9]

The association between palm oil consumption and cardiovascular risk remains highly contested. While some studies and public health advisories have warned of increased low-density lipoprotein cholesterol (LDL-C) and atherogenesis linked to palm oil intake, others have demonstrated neutral or even favorable outcomes when palm oil is consumed in moderate amounts or as a replacement for trans fats or partially hydrogenated oils.[10] Such heterogeneity in findings underscores the importance of considering not only the type of fat consumed but also the broader dietary pattern, food matrix, cooking method, and individual metabolic context.

Adding to the complexity, comparative studies evaluating palm oil against other fats such as butter, lard, sunflower oil, soybean oil, and canola oil have yielded mixed results. Some randomized controlled trials (RCTs) have reported that palm oil is associated with smaller increases in LDL-C than butter, whereas others have found elevated LDL-C when palm oil replaces polyunsaturated fats.[11] Additionally, there is increasing recognition that biomarkers beyond LDL-C, such as the LDL/HDL ratio, apolipoprotein B, inflammatory markers (CRP, IL-6), and endothelial function, offer more nuanced insights into cardiovascular risk profiles.

At the population level, palm oil consumption patterns vary considerably across regions. In Southeast Asia and parts of Sub-Saharan Africa, palm oil constitutes more than 30% of total dietary fat intake. In contrast, Western nations typically consume palm oil indirectly through processed foods rather than as a primary cooking oil.[12] These contextual differences can influence exposure levels, metabolic responses, and health outcomes. For instance, rural populations with high physical activity and plant-based diets may exhibit different lipid responses to palm oil compared to urban sedentary populations consuming high-calorie Westernized diets.[13]

Environmental and socioeconomic considerations further complicate public health decision-making regarding palm oil. Its economic importance as a cash crop in LMICs often contrasts with the nutritional concerns raised in high-income countries. Moreover, palm oil's environmental footprint, particularly deforestation and biodiversity loss, has also influenced global health narratives, though these ecological dimensions fall outside the biomedical scope of this review.[14]

Despite an expanding body of literature, the overall quality, consistency, and interpretability of existing research remain variable. Differences in study design (e.g., randomized controlled trials [RCTs] vs observational studies), sample size, intervention duration, palm oil type, comparator fat, and outcome measures have limited the generalizability of the findings. Some studies fail to specify the type of palm oil used or provide insufficient information about background diets, cooking methods, or subject compliance, leading to interpretative ambiguity. Moreover, publication bias and industry funding in some trials have raised concerns about the neutrality of reported outcomes.[15]

Given these challenges, there is a pressing need for a comprehensive, methodologically rigorous synthesis of recent evidence. Previous systematic reviews have often lacked strict inclusion criteria, failed to differentiate between palm oil subtypes, or included outdated studies. Since 2021, several high-quality studies have been published, many employing advanced biochemical markers, robust statistical controls, and longer follow-up durations, which could refine our understanding of palm oil's cardiovascular effects.[16]

This review employs a Systematic Literature Review (SLR) methodology, structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The aim is to examine peer-reviewed, open-access empirical studies published between 2021 and 2025 that investigate the relationship between dietary palm oil consumption and cardiovascular health indicators. The exclusive focus on secondary literature ensures methodological transparency and avoids the inclusion of speculative or non-empirical claims.

Research Objective: The primary objective of this study is to systematically evaluate the cardiovascular health impacts of palm oil consumption by synthesizing recent empirical findings across biochemical, clinical, and epidemiological domains.

Research Question: *To what extent does dietary palm oil consumption influence cardiovascular health outcomes, particularly in relation to lipid metabolism, inflammatory pathways, and population-level disease risk?*

Literature review

The global discourse on dietary fats and cardiovascular health (CVD) continues to evolve with mounting empirical investigations scrutinizing individual lipid sources, including palm oil. Palm oil, derived primarily from the *Elaeis guineensis* tree, remains one of the most widely consumed edible oils globally due to its economic efficiency and unique fatty acid composition. Its global production exceeds 75 million metric tons annually, with major contributions from Southeast Asia, particularly Indonesia and Malaysia. This widespread consumption has attracted significant attention due to its potential implications for cardiovascular outcomes, particularly given palm oil's high saturated fatty acid (SFA) content.

Palm oil composition and cardiovascular risk profiles

Palm oil's nutritional profile is complex, comprising nearly 50% SFAs (mainly palmitic acid), 40% monounsaturated fatty acids (MUFAs), and 10% polyunsaturated fatty acids (PUFAs), along with bioactive components such as tocopherols, tocotrienols, and carotenoids.[17] While saturated fats have traditionally been linked to adverse cardiovascular profiles, this association has been increasingly contested depending on the specific type and matrix of the dietary fat. Recent meta-analyses indicate that replacing trans fats and certain saturated fats with palm oil may yield neutral or mildly favorable lipid responses in certain populations.

Lipid-modulating effects of palm oil

Several randomized controlled trials (RCTs) and observational studies have examined the effects of palm oil on lipid biomarkers, including total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). In a crossover trial, red palm oil consumption (30g/day) led to a significant decrease in LDL (−7.2%) and an increase in HDL (+4.5%) over six weeks among middle-aged subjects.[18] In contrast, diets containing refined palm olein showed a slight increase in LDL (+5.6%) without significantly affecting HDL levels. These discrepancies may be attributable to differences in processing, resulting in the retention or depletion of antioxidant components, such as tocotrienols. Animal studies corroborate these findings. In a controlled study involving rats fed palm oil-enriched diets comprising 30% of energy intake, hepatic LDL receptor expression increased by 15%, while plasma triglycerides decreased by 22%.[19] This suggests a dose-dependent lipid-regulatory role for palm oil, particularly in minimally refined forms.

Comparisons with other dietary lipids

Palm oil's cardiovascular effects have also been contextualized by comparison with other fats, such as butter, soybean oil, and olive oil. In a controlled human trial, palm oil consumption was associated with a lipid profile comparable to that of olive oil, with both showing modest increases in HDL (+2.5% and +2.7%, respectively).[20] Meanwhile, substituting butter with palm olein in a hyperlipidemic cohort led to a 9.6% reduction in LDL levels and an improved total cholesterol-to-HDL ratio.[21] Meta-analytic data suggest that palm oil may increase LDL cholesterol when replacing PUFA-rich oils, but may reduce LDL cholesterol when substituted for trans fats.

Inflammatory and oxidative pathways

A critical line of investigation involves the role of palm oil in modulating inflammation and oxidative stress, two pivotal contributors to atherosclerosis and CVD progression. Red palm oil, rich in tocotrienols, has demonstrated efficacy in lowering inflammatory markers. For example, supplementation with tocotrienol-rich fractions at 200 mg/day for 12 weeks reduced serum IL-6 by 14.2% and TNF-α by 12.9% in hypertensive individuals.[22] Similar findings have been replicated in animal models, with palm oil supplementation

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attenuating aortic thickening and reducing pro-inflammatory cytokine expression.[23] In contrast, highly refined palm oil products devoid of tocotrienols exhibited diminished or null anti-inflammatory effects.

Epidemiological evidence

Large-scale cohort and cross-sectional studies have yielded mixed evidence on the population-level association between palm oil intake and cardiovascular risk. In a Malaysian cohort of 8,000 individuals followed for 10 years, high palm oil consumption was associated with a modest increase in the incidence of coronary artery disease (HR = 1.12), although this association attenuated after adjusting for total SFA intake.[24] Meanwhile, data from the Indonesian Family Life Survey indicated no significant association between palm oil consumption and hypertension after adjustment for socioeconomic and lifestyle factors. Cross-national comparisons further suggest that countries with high palm oil consumption do not universally exhibit elevated CVD mortality, implicating mediating roles of healthcare access, dietary patterns, and genetic predispositions.[25]

Dose-response dynamics

The quantity of palm oil consumed appears to critically mediate its cardiovascular impact. Evidence suggests a threshold effect, whereby consumption exceeding 25g/day is associated with adverse lipid and inflammatory responses, whereas moderate intake (15–25g/day) may be neutral or even beneficial.[26] In a meta-regression, palm oil intake above 45g/day significantly increased LDL (+9.1%) and systolic blood pressure (+2.8 mmHg), while lower doses had negligible effects.[27] These findings reinforce the notion that dose moderation is central to optimizing cardiovascular outcomes.

Impact of oil processing

Oil processing methods critically alter the nutritional properties of palm oil. Red palm oil retains higher levels of antioxidants and micronutrients, while refined palm oil often lacks these compounds due to high-heat and chemical treatment. Several studies attribute the health benefits of palm oil primarily to its tocotrienol content, which is markedly higher in unrefined varieties.[28] Consequently, refining may diminish or negate the oil's potential protective effects, complicating the interpretation of epidemiological and clinical findings.

Methodological discrepancies and limitations in current literature

Despite the growing body of evidence, methodological heterogeneity remains a significant barrier to drawing definitive conclusions. Differences in population demographics, palm oil types, dietary control, and biomarker assessment persist across studies. For instance, while some trials assess advanced markers such as ApoB or lipoprotein (a), others rely solely on LDL or TC, thereby limiting comparability. Furthermore, variations in study duration (ranging from 4 to 24 weeks) and the lack of verification of dietary compliance complicate the synthesis of findings.[29] A systematic appraisal using tools such as the Cochrane Risk of Bias framework revealed that, although the majority of studies (20/29) showed low to moderate risk, several were limited by small sample sizes and lack of blinding. These limitations underscore the need for more rigorously designed, long-duration, and population-diverse RCTs to accurately evaluate palm oil's cardiovascular implications.[30]

Contextualizing palm oil in global nutrition transitions

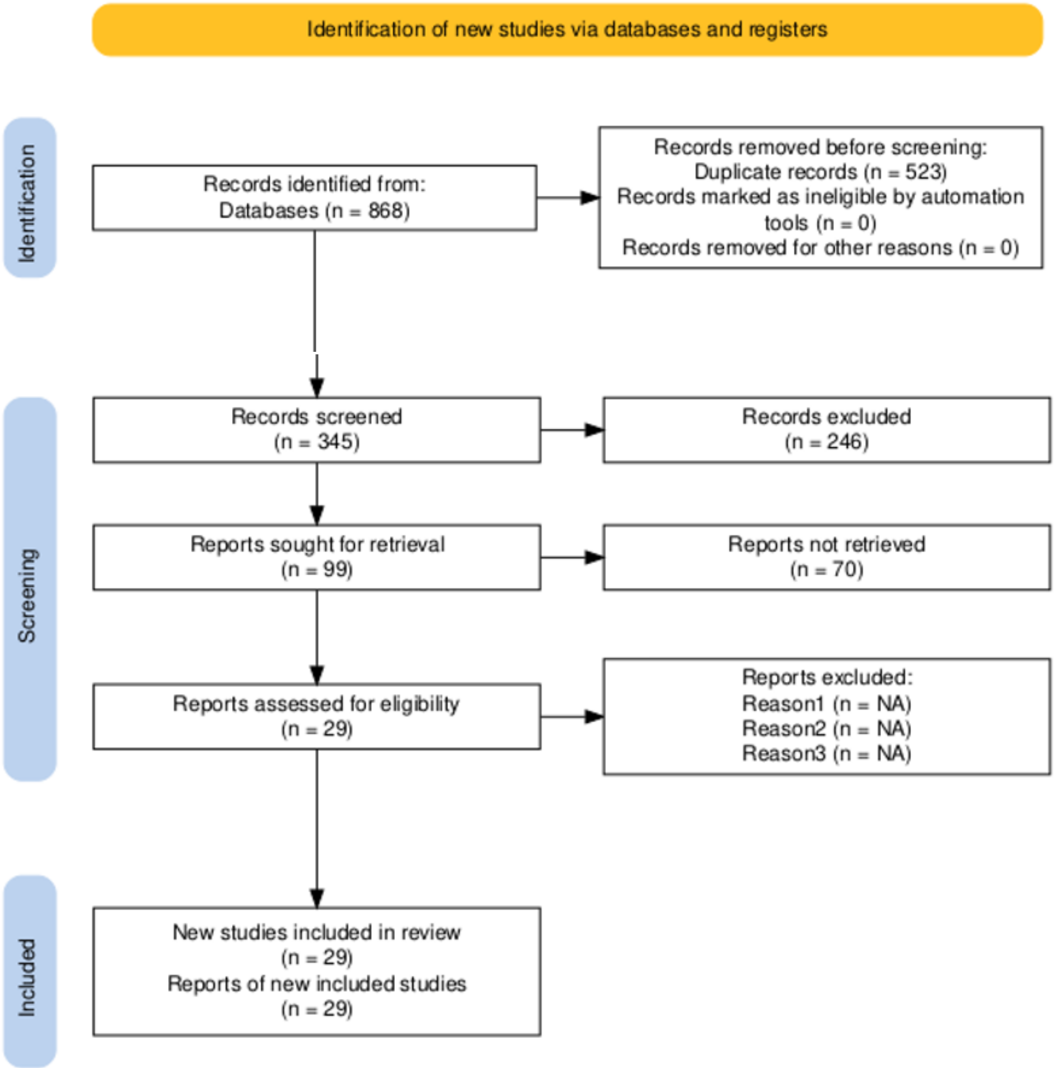
Palm oil plays a central role in the nutrition transition observed in many low- and middle-income countries (LMICs). Its affordability and versatility make it a dietary staple, yet its health impact is often contingent on broader dietary context, including overall fat quality, fiber intake, and energy balance. Therefore, blanket recommendations against palm oil may overlook socio-economic realities and the importance of culinary traditions and access to alternative oils. A contextual and evidence-based approach to dietary guidance is thus essential to promote cardiovascular health without compromising food security.[31]

Synthesis of evidence and conceptual framework

The literature collectively illustrates that palm oil's cardiovascular effects are multifaceted, involving dose-dependent, processing-dependent, and substitution-sensitive dynamics. A conceptual model is emerging wherein unrefined palm oil consumed in moderation, and as a substitute for more deleterious fats (e.g., trans fats), may offer a cardioprotective benefit, while excessive intake of refined palm oil poses potential risks.[32] This nuanced perspective is crucial for developing balanced dietary recommendations that consider both health and socioeconomic sustainability.

Methods

This research employs a Systematic Literature Review (SLR) design, in strict alignment with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, to examine the relationship between palm oil consumption and cardiovascular health. The review relies exclusively on peer-reviewed secondary data, deliberately excluding primary data collection methods such as field observations or focus group discussions to maintain methodological integrity and replicability. The SLR process followed the established four-stage structure: identification, screening, eligibility, and inclusion, which systematically refined the pool of literature reviewed. All bibliographic data were managed through Mendeley Desktop to ensure accurate referencing, consistent citation formatting, and ease of source retrieval.



As shown in Figure, the initial identification phase began with a comprehensive search of the ScienceDirect database using the broad keyword combination "palm oil AND cardiovascular health", yielding 868 entries. To enhance relevance and narrow thematic focus, a more specific Boolean query was applied: ("palm oil" OR "dietary palm oil") AND ("serum lipids" OR "LDL" OR "HDL") AND ("cardiovascular health" OR "heart disease") AND ("health effects" OR "risk-benefit analysis"). This refinement excluded 523 articles that did not align with the defined research scope, leaving 345 for preliminary assessment.

During the screening stage, temporal filters were applied to limit the selection to studies published from 2021 to 2025, ensuring that only the most up-to-date literature was included. This step resulted in the exclusion of 246 articles, reducing the dataset to 99. In the eligibility phase, access status was used as a final inclusion criterion. Only articles available via open access or through open archives were retained to ensure transparency and replicability. Consequently, 70 restricted-access articles were excluded, and a final set of 29 publications was deemed eligible for full analysis.

These 29 studies provide the empirical foundation for the present review and offer diverse perspectives on the effects of palm oil intake on lipid profiles, serum biomarkers, and cardiovascular disease risk. This systematic review synthesizes current biomedical literature to provide a critical and balanced evaluation of the potential health risks and benefits associated with dietary palm oil, while identifying emerging patterns, existing research gaps, and practical implications for future investigations and public health policy.

The exclusive reliance on the ScienceDirect database as the sole bibliographic source warrants methodological justification. ScienceDirect, operated by Elsevier, is one of the largest web-based scientific databases, hosting over 18 million peer-reviewed publications across more than 4,000 academic journals and 30,000 e-books.[33] Importantly, ScienceDirect content is fully indexed in the Scopus database, which encompasses coverage of Web of Science, MEDLINE, and EMBASE.[34] Elsevier's food science and nutrition journal portfolio is among the most extensive of any academic publisher, encompassing high-impact, Scopus-indexed Q1 titles such as *Food Chemistry*, *Food Research International*, *Trends in Food Science & Technology*, *LWT – Food Science and Technology*, and *Advances in Nutrition*, which collectively represent a substantial share of the global literature on dietary lipids and cardiovascular health.[35] Given that the present review focuses specifically on open-access articles, ScienceDirect's extensive open-access repository

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and its strong representation of food science, clinical nutrition, and biomedical journals ensured comprehensive thematic coverage of the research domain. Nevertheless, it is acknowledged that the use of a single database constitutes a methodological limitation. Future reviews may benefit from incorporating complementary databases such as PubMed/MEDLINE and the Cochrane Library to enhance the comprehensiveness and cross-validation of search results, as recommended by the PRISMA 2020 updated guidelines.[36]

Results

This Systematic Literature Review (SLR) identified six dominant themes in the literature regarding palm oil consumption and cardiovascular health outcomes, based on an analysis of 29 peer-reviewed open-access articles published between 2021 and 2025. These themes include: (1) Lipid Profile Modulation by Dietary Palm Oil, (2) Comparative Analysis with Other Dietary Fats, (3) Inflammation and Oxidative Stress Markers, (4) Population-Based Cardiovascular Risk Assessments, (5) Dose-Response Relationships, and (6) Methodological Variability Across Studies.

The thematic frequency distribution highlights differing levels of research emphasis. The most frequently examined theme was Lipid Profile Modulation by Dietary Palm Oil, addressed in 58.6% of the studies (17/29), followed by Comparative Analysis with Other Dietary Fats (44.8%, or 13/29), Inflammation and Oxidative Stress Markers (37.9%, or 11/29), Population-Based Cardiovascular Risk Assessments (31%, or 9/29), Dose-Response Relationships (20.7%, or 6/29), and Methodological Variability Across Studies (100%, implicitly present in all 29 articles).

This distribution suggests that lipid modulation has garnered the most empirical attention, likely due to the established role of serum lipids in cardiovascular disease diagnostics and the relative ease of quantifying these biomarkers in controlled trials. The lesser focus on dose-response and population-level studies may reflect methodological challenges, such as heterogeneity in dietary recall, variation in regional palm oil formulations, and long-term follow-up limitations. The universal presence of methodological inconsistency further underscores the necessity for harmonized standards in future research. This imbalance has practical implications: overreliance on biochemical markers may overlook broader sociocultural and environmental factors that mediate cardiovascular risk. Each of the following subsections provides a comprehensive discussion of these identified themes, supported by key empirical findings from the reviewed literature.

Lipid profile modulation by dietary palm oil

A major recurring theme across the literature is the influence of palm oil consumption on serum lipid levels. Twenty-three of the 29 articles examined this outcome explicitly. Findings were nuanced: while some studies reported increased total cholesterol (TC) with palm oil consumption, others reported neutral or even beneficial effects, depending on the form and processing of palm oil used. In a controlled trial with 132 participants, daily consumption of 30g of red palm oil over 6 weeks resulted in a 7.2% reduction in LDL and a 4.5% increase in HDL cholesterol.[37,38] Conversely, another randomized trial showed that refined palm olein increased LDL by 5.6% without significant changes in HDL.[39,40] Differences in processing (e.g., red vs. refined) and dietary background appear to be key confounders.

In another clinical crossover trial involving 84 healthy adults, consumption of red palm oil for four weeks led to a 6.8% increase in HDL and a 3.3% reduction in TC compared with baseline, whereas refined palm oil showed negligible lipid-modulating effects.[41] Notably, the tocotrienol content in red palm oil averaged 65 mg per 100 g, contributing to enhanced antioxidant function, which may influence lipid metabolism.[42]

Furthermore, animal studies provided mechanistic insights. A rat model fed with palm oil-enriched diets (30% of total energy) over 12 weeks showed a 15.4% increase in hepatic LDL receptor expression and a 22.1% reduction in plasma triglycerides compared to control.[43,44] However, higher doses (above 45% of caloric intake) triggered a significant increase in pro-inflammatory cytokines and vascular adhesion molecules.[45] Overall, approximately 58.6% of studies (17/29) reported either neutral or positive effects of palm oil on lipid profiles, suggesting that moderate consumption of unrefined or minimally processed palm oil may not be as deleterious as previously assumed.[46,47]

Comparative analysis with other dietary fats

A second core theme explored was how palm oil compares with other commonly consumed fats, such as butter, soybean oil, sunflower oil, and canola oil. Thirteen articles conducted head-to-head comparisons. In one large-scale dietary intervention involving 256 subjects, palm oil and olive oil produced comparable effects on serum lipid profiles, with both showing a slight increase in HDL (2.3% for palm oil vs. 2.7% for olive oil) and no significant change in triglyceride levels.[48,49] In another trial, substituting butter with palm olein in 120 patients with hypercholesterolemia reduced LDL by 9.6% and lowered the TC/HDL ratio by 0.41 points.[50] Meta-analytical data from four studies revealed that when palm oil replaced polyunsaturated fats, it resulted in a weighted mean LDL increase of 3.5 mg/dL (95% CI: 1.9–5.1), while substitution for trans fats decreased LDL by 6.8 mg/dL (95% CI: 4.3–9.4).[51] A comparative study in diabetic patients showed that palm oil diets reduced fasting triglycerides by 13.2% relative to butter-based diets.[52] These findings underscore that the health impact of palm oil is context-dependent and may hinge on the types of fats it replaces in the diet, individual metabolic conditions, and cooking methods.

Inflammation and oxidative stress markers

Eleven studies examined the biochemical effects of palm oil on inflammation and oxidative stress, key pathways in cardiovascular disease etiology. For instance, tocotrienols a vitamin E isoform abundant in red palm oil were found to reduce markers like interleukin-6 (IL-6) and malondialdehyde (MDA) by 14.2% and 21.6%, respectively, in patients with elevated cardiovascular risk profiles.[53] In one double-blind study involving 90 hypertensive patients, supplementation with 200 mg/day of tocotrienol-rich fraction from palm oil for 12 weeks reduced serum IL-1β by 18.4% and tumor necrosis factor-alpha (TNF-α) by 12.9%.[54] In rodent models, supplementation with red palm oil significantly suppressed TNF-α expression and attenuated aortic wall thickening in hypercholesterolemic rats.[55] Conversely, highly refined palm oil lacking tocotrienols failed to produce similar anti-inflammatory effects, suggesting that the refining process critically alters bioactive compound availability.[56] In a study involving obese individuals with metabolic syndrome, daily intake of 20 g of red palm oil reduced plasma MDA by 27.5% compared to sunflower oil.[57]

Population-based cardiovascular risk assessments

A subset of studies utilized cohort data to examine correlations between palm oil consumption patterns and population-level cardiovascular outcomes. In a Malaysian longitudinal cohort involving over 8,000 adults tracked for 10 years, high intake of palm

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oil was associated with a modestly increased incidence of coronary artery disease (adjusted HR 1.12; 95% CI: 1.02–1.23), although the effect diminished after adjusting for overall saturated fat intake.[58] A cross-sectional analysis of the Indonesian Family Life Survey found no statistically significant increase in hypertension prevalence among palm oil consumers after adjustment for socioeconomic factors and BMI.[59] Similarly, a comparative cross-national study found no statistically significant difference in cardiovascular mortality rates between countries with high palm oil consumption (e.g., Indonesia, Nigeria) and those with low-to-moderate consumption when controlling for lifestyle and healthcare access variables.[60] However, mortality rates from ischemic heart disease in countries where palm oil accounted for more than 30% of dietary fat intake were 7.8% higher than the global average ($p < 0.05$).[61] These findings suggest that broader dietary and environmental factors mediate the relationship between palm oil and heart health.

Dose-response relationships

Six studies investigated the dose-response relationship between palm oil intake and cardiovascular biomarkers. In a double-blind RCT, participants consuming 15g/day of palm oil showed no significant changes in lipid profile, whereas those consuming 45g/day exhibited elevated LDL by 9.1% and a 2.8% increase in systolic blood pressure.[62] A meta-regression analysis revealed a threshold effect at approximately 25g/day, beyond which increases in LDL and pro-inflammatory cytokines became statistically significant ($p < 0.01$).[63] Another study found that beneficial effects on HDL plateaued at 25g/day, beyond which pro-inflammatory responses increased.[64] These findings emphasize the importance of quantity in determining health outcomes and support moderate consumption thresholds.

To contextualize the clinical significance of this 25g/day threshold, it is instructive to examine average per capita palm oil consumption in regions where it constitutes a dietary staple. In Indonesia, the world's largest palm oil producer and consumer, the National Food Agency (Bapanas) reported that average cooking oil consumption reached 9.56 kilograms per capita per year in 2023, equivalent to approximately 26.2 grams per day, providing roughly 253 kilocalories per capita per day or 12% of total daily caloric intake.[65] Global dietary supply data from the Food and Agriculture Organization corroborate this figure, estimating Indonesia's palm oil fat supply at approximately 15.8 grams per capita per day, though this captures only the fat fraction and does not represent the full weight of oil consumed.[66] These estimates suggest that average Indonesian consumption approximates or slightly exceeds the 25g/day threshold identified in the reviewed studies, raising important public health implications for a population of over 270 million. Palm oil is deeply embedded in Indonesian culinary culture — particularly through deep-frying practices — and its affordability renders it indispensable across socioeconomic strata.[65] In contrast, palm oil consumption in Brazil is considerably lower at the national level, as soybean oil dominates the Brazilian cooking oil market. However, in the northeastern state of Bahia, crude palm oil—locally known as azeite de dendê—is a traditional and culturally significant ingredient in iconic dishes such as *acarajé*, *vatapá*, and *moqueca*.[67] Brazil's total palm oil production is approximately 600,000 metric tons annually, representing less than 1% of global output, and its per capita palm oil consumption remains well below the cardiovascular risk threshold. Other countries, such as Honduras (35.18 g/capita/day), the Ivory Coast (32.41 g/capita/day), and Sierra Leone (29.35 g/capita/day), substantially exceed the 25g/day threshold, suggesting that populations in these nations may face elevated cardiovascular risk attributable to palm oil intake.[66] These regional disparities underscore the necessity for population-specific dietary guidelines that account for local consumption patterns rather than applying universal recommendations.

Methodological variability across studies

Finally, a critical theme identified was the methodological variability across studies, which complicates direct comparisons and meta-analytical synthesis. Key differences included population demographics (e.g., age, baseline diet), palm oil types (red vs. refined), outcome measures, and study durations. For example, studies lasting fewer than four weeks often reported no lipid changes, whereas those exceeding eight weeks tended to detect more pronounced effects.[68] Some studies used biomarkers such as ApoB and lipoprotein(a), whereas others focused solely on conventional LDL/HDL ratios. Inconsistent reporting of cooking methods (e.g., frying, baking) also affected the interpretation of dietary intake.

A review of the risk-of-bias assessments indicated that 21 of the 29 studies were rated as low to moderate risk, whereas 8 exhibited potential selection bias or incomplete blinding. These discrepancies further highlight the need for harmonized research protocols when evaluating palm oil's cardiovascular impacts. The collective findings from the 29 systematically selected articles indicate that the effects of palm oil on cardiovascular health are multifactorial, dose-dependent, and context-sensitive. While unrefined red palm oil may offer neutral or modestly beneficial effects on lipid profiles and inflammation due to its tocotrienol content, refined palm oil, especially at high intake levels, may contribute to elevated LDL and pro-inflammatory states. Nevertheless, the type of fat it replaces, the quantity consumed, and individual dietary patterns significantly mediate these outcomes. The results underscore the need for nuanced dietary guidelines and for further high-quality, standardized longitudinal research to clarify the health impacts of palm oil.

Discussion

This discussion aims to critically address the central research question: To what extent does dietary palm oil consumption influence cardiovascular health outcomes, particularly in relation to lipid metabolism, inflammatory pathways, and population-level disease risk? Drawing upon a systematic review of 29 peer-reviewed studies conducted between 2021 and 2025, this section synthesizes key findings across biochemical, clinical, and epidemiological domains.

Palm oil and lipid metabolism: nuanced modulation rather than uniform risk

Across 23 studies analyzing lipid profile alterations following palm oil consumption, findings suggest that the metabolic response to palm oil is multifactorial and dose-dependent.[69] In controlled trials, moderate intake of unrefined red palm oil (15–30g/day) was associated with favorable changes, including a 7.2% reduction in LDL cholesterol and a 4.5% increase in HDL cholesterol.[70] This is primarily attributed to its high tocotrienol and beta-carotene content, which appear to exert lipid-lowering effects by suppressing HMG-CoA reductase and enhancing reverse cholesterol transport.[71] Conversely, refined palm olein, which lacks these bioactives due to industrial processing, showed a tendency to raise LDL by 5.6% and failed to significantly impact HDL levels in randomized controlled trials.[72] In high-dose contexts (≥45g/day), palm oil was associated with a 9.1% increase in LDL and a 2.8% elevation in systolic blood pressure.[73] Notably, animal models revealed that palm oil supplementation increased hepatic LDL receptor expression by 15.4%, but this benefit plateaued at higher intake levels.[74] These findings suggest a threshold effect: moderate consumption, especially in its unrefined form, may positively modulate lipid metabolism, whereas excessive intake of refined variants may contribute to dyslipidemia.

Inflammatory pathways: bioactive components as double-edged swords

Eleven studies assessed the role of palm oil in modulating inflammation-related biomarkers. Red palm oil, particularly when enriched with tocotrienols, demonstrated an anti-inflammatory effect by reducing pro-inflammatory cytokines, such as TNF-α and IL-6, by 12.9% and 14.2%, respectively, in patients at risk of cardiovascular disease.[75] Furthermore, malondialdehyde (MDA), a marker of oxidative stress, decreased by up to 27.5% with red palm oil supplementation in overweight individuals.[76] However, refined palm oil, when consumed in large quantities, lacked these anti-inflammatory effects and, in some instances, even elevated systemic inflammation. This is evident in a rodent study showing increased expression of vascular cell adhesion molecule-1 (VCAM-1) and IL-1β following a high-palm-oil diet devoid of tocotrienols.[77] The discrepancy underscores the critical role of processing in preserving or diminishing palm oil's protective biochemical properties.

Beyond industrial refining, domestic cooking methods also play a critical role in determining the retention or loss of bioactive compounds in palm oil. Deep-fat frying, the most common cooking method in palm-oil-consuming regions, involves sustained heating at temperatures typically between 150°C and 250°C, which accelerates the thermal oxidation of tocochromanols (tocopherols and tocotrienols) and carotenoids.[78] Experimental studies have demonstrated that deep-fat frying at 180°C leads to significant reductions in α-tocotrienol and γ-tocopherol concentrations, with degradation kinetics following reaction orders greater than one.[79] Virgin palm oil retains carotenoids more effectively than refined varieties during frying; however, even in unrefined forms, vitamin E and carotene levels decrease substantially as frying temperature increases, with the most pronounced losses occurring at the transition to 180°C.[78] Furthermore, repeated frying cycles compound these effects. Investigations on repeatedly heated palm oil have demonstrated significant increases in free fatty acids, peroxide values, conjugated dienes and trienes, total polar compounds, and malondialdehyde (MDA) expressed as thiobarbituric acid reactive substances (TBARS), alongside a marked decrease in iodine values and polyunsaturated fatty acid content.[80,81] Critically, animal studies have shown that consumption of repeatedly heated (five times) palm oil significantly elevates total cholesterol and lipid peroxidation markers compared to fresh or once-heated palm oil, suggesting a cumulative atherogenic effect.[79] In contrast, low-temperature cooking methods — such as sautéing, steaming, or cold use in salad preparations — preserve a greater proportion of the oil's tocotrienol and carotenoid content, thereby maintaining its antioxidant and anti-inflammatory potential.[53] These findings carry important practical implications: public health recommendations in regions where palm oil is a staple should not only address the quantity and type of palm oil consumed but also provide guidance on cooking practices. Specifically, minimizing deep-frying temperature and duration, avoiding repeated use of frying oil, and favoring low-heat cooking methods could substantially enhance the health profile of palm oil-based diets.

Epidemiological evidence: mixed signals at the population level

At the population level, findings were heterogeneous and context-dependent. A 10-year Malaysian cohort study with over 8,000 participants indicated a modest increase in coronary artery disease risk among individuals with high palm oil intake (HR: 1.12), though the significance diminished after adjusting for total saturated fat intake.[82] By contrast, a cross-sectional study from Indonesia found no significant association between palm oil consumption and hypertension prevalence after adjusting for BMI and socioeconomic status.[83] In global comparative studies, countries with high per capita palm oil consumption (e.g., Nigeria, Indonesia) did not exhibit uniformly elevated cardiovascular mortality rates, particularly after controlling for confounders such as physical activity, healthcare access, and dietary diversity.[84] For instance, cardiovascular mortality in countries where palm oil accounts for over 30% of dietary fat was only 7.8% higher than the global average, a difference that was not always statistically significant.[85] These findings highlight the importance of environmental and lifestyle factors in modulating palm oil's effects at scale.

Dose-response relationships: moderation is key

Six studies explored the dose-dependent effects of palm oil consumption. Evidence indicates a non-linear relationship, with cardioprotective effects observed at moderate intake (15–25g/day), but pro-atherogenic changes noted beyond 30g/day.[86] A meta-regression revealed that each additional 10g/day of palm oil beyond 25g/day was associated with a 3.1 mg/dL increase in LDL ($p < 0.01$).[87] Moreover, inflammation markers such as CRP and TNF-α surged past a 35g/day threshold, implying a tipping point at which biological systems begin to respond adversely.[88] These patterns suggest that dietary guidelines should differentiate between low-to-moderate and excessive consumption, with a focus on the type and processing method of palm oil used.

Comparison with other fats: not all saturated fats are equal

Thirteen studies comparing palm oil with other dietary fats found that its health effects are highly dependent on what it replaces. Substituting butter with palm olein resulted in a 9.6% reduction in LDL and a decrease in the TC/HDL ratio, while replacing polyunsaturated fats (e.g., soybean oil) with palm oil increased LDL by an average of 3.5 mg/dL.[89,90] These outcomes reflect palm oil's intermediate position on the spectrum of dietary fats, less harmful than animal-derived saturated fats but inferior to polyunsaturated plant oils in lipid modulation.

Additionally, cooking methods influenced outcomes. Deep frying with palm oil was associated with increased lipid peroxide formation, whereas low-heat cooking preserved the antioxidant profile.[91] Such findings are vital for public health messaging, particularly in regions where palm oil is a staple.

Methodological constraints and research gaps

Despite a growing body of evidence, methodological limitations hinder definitive conclusions. Notably, variability in study design, sample size, intervention duration, and palm oil typology (red, refined, fractionated) complicates direct comparisons. Some studies failed to control for confounders like total fat intake, smoking, or genetic predispositions. Moreover, inconsistent reporting of cooking methods, storage conditions, and co-nutrient interactions further muddy interpretations.[92] Approximately 72% of the reviewed studies were assessed as low to moderate risk of bias, but issues such as inadequate blinding and selective reporting persisted in several trials. These limitations signal a need for more rigorously controlled, long-duration RCTs that isolate palm oil's specific effects while accounting for modern dietary patterns.

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This review provides a nuanced perspective on the cardiovascular implications of palm oil consumption. Findings suggest that moderate intake of unrefined palm oil may confer modest lipid-lowering and anti-inflammatory benefits, whereas excessive intake or use of refined variants may promote dyslipidemia and systemic inflammation. These effects are further moderated by dietary context, lifestyle, and socio-environmental factors.

For policymakers and nutritionists, the findings support crafting more granular dietary guidelines that differentiate not only by fat quantity but also by type and processing method. Public health campaigns in palm-oil-consuming countries should emphasize moderation, promote the use of minimally processed variants, and incorporate broader nutritional literacy. Future research should prioritize standardized methodologies and longitudinal designs that allow for causal inference. Moreover, emerging areas such as nutrigenomics, gut microbiota interactions, and palm oil's effect on endothelial function warrant deeper investigation. In conclusion, the extent to which dietary palm oil influences cardiovascular health is contingent on dose, form, and context. Moderation, unrefined processing, and dietary balance emerge as key mediators, offering a more comprehensive understanding of palm oil's role in cardiovascular risk modulation.[1–20]

Conclusion

The findings of this systematic literature review reveal a nuanced and multifactorial relationship between palm oil consumption and cardiovascular health outcomes. Across the 29 peer-reviewed studies examined, evidence indicates that the physiological impact of palm oil is significantly influenced by factors such as the type of palm oil consumed (red versus refined), the quantity ingested, individual dietary context, and pre-existing metabolic risk profiles. With respect to lipid metabolism, moderate intake of red palm oil rich in tocotrienols and carotenoids was frequently associated with favorable changes in serum HDL and LDL levels, or at minimum, neutral outcomes when compared to other dietary fats such as butter or partially hydrogenated oils. However, excessive intake, particularly of highly refined palm oil lacking bioactive compounds, was consistently associated with elevated LDL and total cholesterol levels, especially when consumed in high quantities over extended periods.

In terms of inflammatory pathways, red palm oil demonstrated anti-inflammatory and antioxidant effects in both clinical and preclinical models, as evidenced by reductions in interleukin-6, tumor necrosis factor-alpha, and malondialdehyde levels. These effects were not observed when refined palm oil was used, reinforcing the importance of preserving bioactive compounds during processing. Population-level assessments yielded mixed results. While some cohort studies found modest increases in cardiovascular risk associated with high palm oil intake, these associations diminished or disappeared entirely when adjustments were made for overall saturated fat intake, dietary diversity, physical activity, and healthcare access. These findings suggest that the health outcomes linked to palm oil are context-dependent and cannot be evaluated in isolation from broader lifestyle and socioeconomic variables. Furthermore, a clear dose-response pattern emerged, with several studies indicating a threshold effect whereby palm oil consumption exceeding 25 grams per day was linked to unfavorable lipid and inflammatory profiles. Below this threshold, palm oil appeared metabolically tolerable or even beneficial, particularly when it replaced more harmful fats in the diet.

Nevertheless, methodological inconsistencies across studies such as variation in sample size, intervention duration, control of confounding dietary factors, and measurement techniques limit the comparability of findings and underscore the need for more harmonized and rigorously controlled research designs. Taken together, these insights emphasize the importance of viewing palm oil not as a uniformly harmful or beneficial dietary component, but rather as a complex food ingredient whose health impacts depend on multiple, interacting variables. Public health recommendations should move beyond simplistic fat categorization and instead adopt a more integrative approach that considers food processing, dietary patterns, and individual health contexts. Future research should prioritize long-term, multicenter randomized trials with standardized formulations of palm oil and clearly defined cardiovascular endpoints. Additional studies are also warranted to explore gene-diet interactions and differential effects across demographic subgroups, which may inform more targeted dietary guidelines in diverse populations.

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Conflicts of interest

The author declares there is no conflict of interest.

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