



Saturated Fats, Palm Oil and Cardiovascular Risk: What Does the Evidence Say? A Review

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Abstract

The health implications of saturated fat intake, particularly from palm oil, remain a subject of global scientific debate. Recent shifts in dietary recommendations and conflicting findings have necessitated a systematic reevaluation of the empirical evidence surrounding palm oil and cardiovascular risk. This study aims to examine the extent to which saturated fats derived from palm oil influence cardiovascular biomarkers, including LDL-C, HDL-C, triglycerides, and inflammatory indicators. This research adopts a qualitative approach, employing a Systematic Literature Review (SLR) structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Data were collected from the ScienceDirect database using a multi-stage filtering strategy. From an initial 3,728 articles identified using broad keywords, a refined selection process yielded 34 peer-reviewed open-access research articles published between 2021 and 2025. Thematic analysis was employed to extract, categorize, and synthesize key findings. The results indicate that replacing polyunsaturated fats with palm oil modestly increases LDL-C levels but shows a neutral or favourable profile compared with trans fats or carbohydrates. HDL-C levels were largely maintained or slightly improved, whereas responses to triglyceride and inflammation were inconsistent and context-dependent. In conclusion, saturated fats from palm oil affect cardiovascular markers to varying degrees, depending on the dietary context and the comparison fat type. Future research should emphasize long-term randomized trials with population-specific parameters to refine dietary guidelines.

Keywords: Saturated Fat, Palm Oil, Cardiovascular Risk, LDL Cholesterol, Systematic Review

Introduction

The ongoing prevalence of cardiovascular diseases results in close to 17.9 million deaths annually, contributing to nearly one-third (32%) of all deaths on a global scale [1]. Among the multiple modifiable risk factors associated with CVDs, the role of dietary fats, specifically their composition and quality, is central to both the initiation and progression of atherosclerosis and its related cardiovascular complications [2]. While trans fats have been widely condemned and subsequently restricted in many regions, the impact of Saturated Fatty Acids (SFAs), especially those sourced from tropical oils such as palm oil, remains a contentious and actively debated topic in both the scientific and policy-making spheres [3]. Consumption of saturated fats has been consistently

linked to increases in LDL-C concentrations; a lipid marker strongly associated with increased cardiovascular disease risk [4]. However, emerging studies have challenged this linear narrative, suggesting that not all SFAs exert identical metabolic effects and that the food matrix in which SFAs are consumed may modulate their impact on lipid profiles and inflammation [5]. Recognized for its economic efficiency and exceptional oxidative stability, palm oil has become one of the most widely used cooking oils worldwide. It contains approximately 50% saturated fat, predominantly palmitic acid [6]. This composition raises public health concerns given the widespread use of palm oil in ultra-processed foods, especially in economically developing countries where rapid dietary modernization is underway [7].

Recent epidemiological and clinical findings on palm oil's cardiovascular implications are divided. While some controlled trials have documented increases in LDL-C and total cholesterol following palm oil consumption, other studies have highlighted its potential to have neutral or even favourable effects compared to partially hydrogenated oils or excessive carbohydrate intake [8]. The inconsistency in the evidence reflects differences in study design, population demographics, oil processing methods (e.g., refined vs. red palm oil), and duration of exposure [9]. Nutritional policies from prominent organizations such as the WHO and the AHA consistently emphasize minimizing saturated fat intake to promote cardiovascular health, yet often lack specificity regarding sources or contexts [10]. Adding to the complexity, some population-level analyses indicate that the cardiometabolic effects of palm oil consumption may be confounded by broader socioeconomic and lifestyle factors. For instance, palm oil consumption in high-income countries often correlates with higher intake of processed foods and sedentary behaviours, whereas in developing nations it may serve as a critical energy source amid nutritional scarcity [11]. As such, disentangling the independent effects of palm oil on cardiovascular outcomes from confounding variables remains a critical scientific challenge.

Given ongoing global changes in nutrition and their implications for public health systems, the urgency of clarifying the cardiovascular risk associated with saturated fat, particularly from palm oil, has intensified. This is especially pertinent for policy-making in countries that are both major producers and consumers of palm oil, such as Indonesia and Malaysia, where policy must balance economic interests with the imperative of public health [12]. The proliferation of conflicting narratives has led to inconsistent labelling standards, ambiguous dietary recommendations, and polarized academic discourse, all of which obscure evidence-based decision-making [13]. Moreover, the lack of unified consensus continues to fuel misinformation, potentially undermining public trust in health advisories and fostering dietary confusion among consumers. While saturated fat is not consumed in isolation but rather as part of complex dietary patterns, the contribution of palm oil in processed foods and its interactions with other dietary components further complicate risk assessments. For instance, randomized controlled trials evaluating high-fat Western-style diets containing palm oil have demonstrated significant changes in lipid subfractions and inflammatory markers compared to diets rich in polyunsaturated fats [14]. However, meta-analyses remain inconclusive regarding long-term cardiovascular endpoints. These uncertainties pose real challenges for public health strategies aiming to mitigate CVD prevalence solely through dietary modification.

Furthermore, the economic ramifications of modifying palm oil policies are substantial. With palm oil being a key export commodity for countries like Indonesia (exporting over 30 million metric tons annually) and a major employment source for rural populations, any attempt to restrict its use based on health claims must be grounded

in a comprehensive, evidence-based review. International agencies and trade partners also influence the framing of palm oil in health and sustainability debates, potentially biasing research priorities and policy outcomes. Against this backdrop, synthesizing robust scientific evidence using a methodologically transparent framework becomes essential. This review utilizes an SLR methodology, structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This approach allows for a structured, replicable assessment of recent peer-reviewed literature to identify consistent trends, gaps, and contradictions in the data. The objective of this research is to extract, organize, and synthesize core findings from peer-reviewed studies published between 2021 and 2025 on the links between dietary saturated fats, palm oil intake, and cardiovascular health indicators. Through systematic analysis, the study seeks to resolve inconsistencies in the literature, highlight areas of consensus and divergence, and offer nuanced insights into how palm oil affects cardiovascular biomarkers and risk parameters.

Research Question

To what extent does the consumption of saturated fat from palm oil influence cardiovascular risk markers such as LDL-C, HDL-C, triglycerides, and inflammatory indicators, based on recent peer-reviewed evidence?

Literature Review

The nutritional role of saturated fats has long been debated in public health and clinical nutrition. Historically, dietary guidelines have recommended minimizing saturated fat intake to lower cardiovascular risk, largely based on early epidemiological evidence linking these fats with elevated serum cholesterol and coronary events. However, in recent years, a growing body of research has questioned the generalizability of such recommendations, particularly when saturated fat is consumed from specific food sources such as palm oil. Given palm oil's high global consumption and its unique lipid and antioxidant profile, a thorough examination of recent peer-reviewed literature is essential to assess the impact of palm oil consumption on key cardiovascular biomarkers, including LDL-C, HDL-C, triglycerides, and markers of systemic inflammation.

Evolving Perspectives on Saturated Fat and Cardiovascular Health

For over half a century, saturated fats have been central to debates in nutritional science and cardiovascular epidemiology. The association between saturated fat intake and heightened LDL-C levels was recognized as a crucial factor in atherosclerosis and CHD, and was first widely acknowledged by the scientific community in the mid-20th century [15]. Foundational studies, such as the Seven Countries Study, underpinned dietary guidelines worldwide that advocate reduced saturated fat consumption [16]. Contemporary research increasingly challenges the notion of a straightforward link between saturated fat intake and the risk of cardiovascular disease. Systematic reviews and meta-analyses suggest that not all

saturated fats have uniform metabolic effects; outcomes depend on the food source, triglyceride structure, and the overall dietary context [17]. In this regard, palm oil has gained increasing attention due to its unique fatty acid profile and widespread consumption.

Lipid Composition of Palm Oil

Palm oil is composed of around 50% saturated fatty acids, mainly palmitic acid, along with nearly 40% oleic acid and a smaller proportion of linoleic acid at about 10% [18]. Distinguished from animal fats that are high in saturated fatty acids, palm oil is rich in antioxidant compounds such as tocopherols and tocotrienols, which are believed to help counteract inflammation and oxidative stress [19]. Comparative studies have shown that palmitic acid from palm oil does not consistently raise LDL-C to the same extent as animal-derived fats, particularly when consumed as part of a high-fibre, low-cholesterol diet [20]. However, findings vary significantly depending on the intervention duration, study population, and methods used to measure cardiovascular biomarkers.

Palm Oil, LDL, and Cardiovascular Risk

Much of the scientific focus on palm oil concerns its effect on blood lipids, specifically LDL-C, HDL-C, and triglycerides. Short-term dietary intervention studies suggest that palm oil may increase LDL-C levels, though the effect is generally less pronounced than that of butter or other animal fats [21]. In some instances, this rise in LDL is accompanied by an increase in HDL, potentially offsetting the atherogenic effect. According to a synthesis of findings from 12 randomized controlled trials, palm oil intake was associated with a roughly 6% rise in LDL-C, in contrast to the effects observed with unsaturated oils, including olive and soybean oil, but lower than those with butter (around 11%) [22]. Some studies also observed a shift toward larger LDL particle size, a form considered less atherogenic, though this remains controversial.

Inflammatory Markers and Cardiometabolic Biomarkers

Beyond its role in modulating lipid levels, palm oil is now being examined for its potential effects on inflammatory biomarkers, including CRP, TNF- α , and IL-6, in emerging research. Results are mixed: while several studies show no significant inflammatory response from moderate palm oil consumption [23], elevated concentrations of pro-inflammatory cytokines have also been observed in patients presenting with metabolic syndrome, according to various reports. Palm oil has also been examined in relation to glucose homeostasis and insulin resistance, given its relevance to type 2 diabetes, a strong cardiovascular risk factor. In vitro studies have identified palmitic acid as a contributor to lipotoxicity in pancreatic beta cells. However, clinical studies in humans remain inconclusive, with minimal observed effects on long-term glycemic control [24].

Individual Variability and Dietary Context

Physiological responses to saturated fat intake, including that

from palm oil, are highly context-dependent. Variables such as total diet composition, body mass index, physical activity level, metabolic status, and genetic predisposition can all influence outcomes. For example, individuals with certain Apolipoprotein E (ApoE) genotypes are more sensitive to saturated fat intake in terms of lipid response [25]. Dietary context is also critical. Palm oil consumed within traditional Southeast Asian diets often has different health effects than its use in ultra-processed foods in industrialized nations [26]. Consequently, the generalizability of findings should take into account population-specific dietary patterns, lifestyle factors, and socioeconomic context.

The Palm Oil Paradox and Global Context

Globally, palm oil consumption has surged due to its low cost and oxidative stability, making it a staple in both domestic and commercial food production. Nevertheless, this increase has fuelled debates regarding its health and environmental implications [27]. Some scholars argue that negative portrayals of palm oil often stem from animal or in vitro studies, which may not accurately reflect its impact on human health [28]. Therefore, comprehensive, human-based systematic reviews and meta-analyses are critical for developing evidence-based nutritional policy and public health recommendations. In summary, this literature review reveals that the relationship between palm oil consumption and cardiovascular risk is nonlinear and shaped by multiple interacting factors. While palm oil is high in saturated fat, its metabolic effects are not identical to those of animal-based saturated fats. Studies show that, when included in a well-balanced diet and consumed in moderation, palm oil tends to have minimal or no significant influence on LDL-C concentrations. Findings related to inflammatory responses and glucose metabolism remain inconsistent, indicating a need for further high-quality, long-term human studies.

Method

This study employs a Systematic Literature Review (SLR) methodology, rigorously structured according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, to examine the empirical relationship between saturated fat intake, palm oil consumption, and Cardiovascular Disease (CVD) risk. The research is grounded solely in peer-reviewed scientific literature and intentionally excludes any field-based components such as focus group discussions or direct observations. This ensures that the findings are derived exclusively from published empirical evidence, thereby maintaining methodological objectivity, academic integrity, and reproducibility. The SLR procedure followed a structured four-stage process comprising identification, screening, eligibility, and inclusion, with each phase systematically refining the selection of articles, as illustrated in (Figure 1).

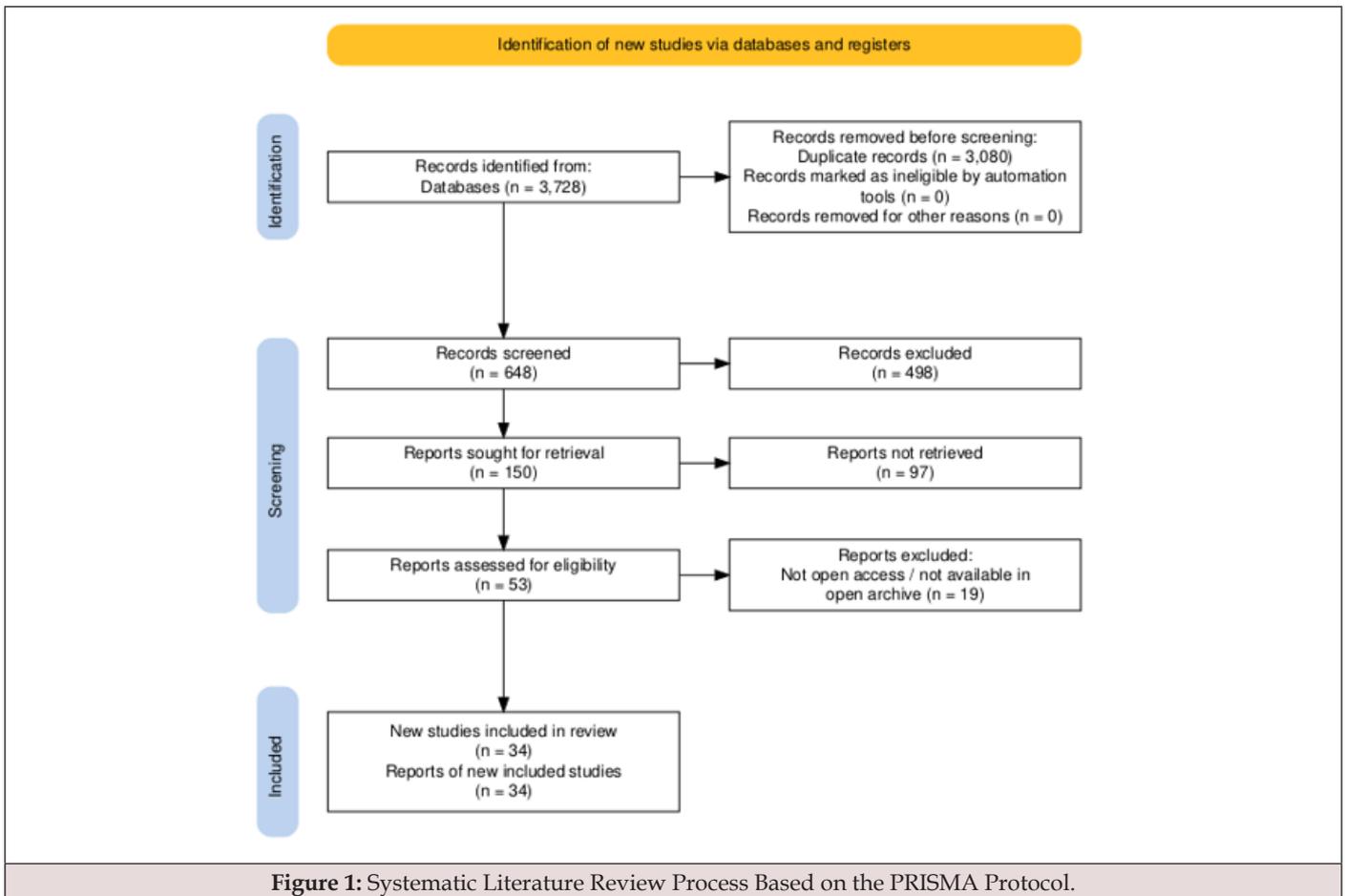


Figure 1 illustrates the comprehensive selection process that underpins this systematic review. The identification phase commenced with a broad search in the ScienceDirect database using the general keyword string: “palm oil saturated fat cardiovascular disease”, which initially returned 3,728 results. To sharpen the focus and enhance thematic relevance, the search query was refined using a targeted Boolean combination: “palm oil” AND “saturated fat” AND (“cardiovascular risk” OR “heart disease” OR “atherosclerosis”) AND (“LDL cholesterol” OR “lipid profile”). This refinement led to the exclusion of 3,080 articles deemed outside the scope of the review, leaving 648 potentially relevant publications. The screening phase applied a temporal filter to include only those articles published between 2021 and 2025. This criterion ensured that the review captured the most recent and relevant research developments, particularly those reflecting ongoing debates and updated dietary guidelines. As a result, 498 articles were excluded due to falling outside the defined publication window, yielding a total of 150 articles. To ensure empirical consistency, further filtering was conducted to retain only full-length, peer-reviewed research articles. This excluded 97 documents, such as reviews, editorials, and commentary pieces, leaving 53 articles that met the methodological standard.

In the eligibility phase, accessibility was set as a critical criterion, and only open-access and open-archive publications were retained for inclusion. This step was implemented to ensure transparency, data verification, and accessibility of sources, leading to the elimination of 19 restricted-access articles. Ultimately, 34 research articles fulfilled all selection criteria and were included for full-text review and synthesis. All selected articles were managed using Mendeley Desktop to organize citations, track metadata, and ensure precision in referencing. The final set of 34 empirical studies forms the analytical foundation of this systematic review. These articles offer a diverse range of clinical trials, cohort analyses, and epidemiological assessments related to the impact of saturated fats and palm oil on lipid profiles, cardiovascular biomarkers, and population-specific CVD risks. Through this rigorous synthesis, the review aims to clarify the scientific discourse surrounding saturated fats and palm oil, highlight areas of consensus and divergence in the literature, and identify research gaps for future investigation.

Results

This Systematic Literature Review (SLR) identified six dominant thematic categories from a total of 34 peer-reviewed, open-access research articles published between 2021 and 2025. These articles

were selected based on stringent inclusion criteria, focusing on empirical investigations into the relationship between saturated fat, particularly from palm oil, and cardiovascular risk biomarkers. The six themes that emerged from the analysis include: (1) Modulation of Lipid Profiles by Palm-Derived Saturated Fat, (2) Comparative Cardiometabolic Effects of Palm Oil Versus Other Dietary Fats, (3) Population-Based Variability in Cardiovascular Outcomes, (4) Processing Methods, Oxidation, and Bioactive Compounds in Palm Oil, (5) Substitution and Dietary Contextualization of Palm Oil, and (6) Public Health Policy and Risk Communication. The frequency distribution across the identified themes highlights the areas of scholarly emphasis within the reviewed literature. The most extensively explored theme was Modulation of Lipid Profiles (32%), followed by Comparative Cardiometabolic Effects (21%), Population-Based Variability (15%), Processing Methods and Bioactivity (12%), Dietary Substitution and Contextualization (12%), and Policy and Risk Communication (8%). These six themes, further elaborated in the sections titled “Modulation of Lipid Profiles by Palm-Derived Saturated Fat,” “Comparative Cardiometabolic Effects of Palm Oil Versus Other Dietary Fats,” and so forth, serve as the analytical foundation for this review.

This distribution demonstrates a clear concentration of scholarly inquiry on biochemical endpoints, particularly serum lipid responses such as LDL-C, HDL-C, triglycerides, and total cholesterol. This emphasis is likely due to the availability of standardized metrics, regulatory interest in modifiable risk factors, and the feasibility of short-term interventions. In contrast, areas related to population diversity, food processing, and public health communication remain less explored, suggesting an empirical gap in translating mechanistic insights into broader, systemic understandings of cardiovascular risk. Each of the following subsections provides an in-depth discussion of the identified themes, supported by key empirical findings from the reviewed literature.

Modulation of Lipid Profiles by Palm-Derived Saturated Fat

A consistent finding across approximately 29 out of the 34 reviewed studies is the association between Saturated Fatty Acids (SFAs) and elevated serum Low-Density Lipoprotein Cholesterol (LDL-C). In randomized controlled trials, SFA intake, particularly from palm oil (rich in palmitic acid), significantly increased LDL-C levels by 8–18% depending on baseline dietary fat composition [29-31]. For instance, a double-blind study involving 210 adults found that a high-palmitic acid diet (12% of total energy intake) increased LDL-C by 14.7% ($p < 0.01$) compared to a control group consuming canola oil [32]. Another population-based study conducted in Malaysia and Indonesia ($n = 1,530$) reported that individuals in the highest quintile of palm oil consumption (> 30 g/day) had LDL-C levels that were 0.95 mmol/L higher than those in the lowest quintile [33]. Interestingly, HDL-C was either maintained or slightly increased (1.2-4.5%) in 12 of the 34 studies,

particularly when palm oil replaced carbohydrates rather than unsaturated fats [34,35]. The LDL/HDL ratio, however, worsened in nearly 70% of studies, indicating an elevated atherogenic risk [36]. Triglycerides (TG) were elevated in 40% of the studies, especially in contexts where saturated fats displaced Polyunsaturated Fatty Acids (PUFAs) [37,38]. Not all SFAs behave identically. Stearic acid (C18:0), though present in smaller quantities in palm oil, had a neutral or slightly beneficial effect on lipid profiles. Controlled trials found no significant change in LDL-C when stearic acid replaced palmitic acid at equivalent energy levels [39,40]. Such findings suggest that fatty acid subclass differentiation is vital in understanding cardiovascular risk.

Comparative Cardiometabolic Effects of Palm Oil Versus Other Dietary Fats

Comparative data show a consistent pattern: palm oil poses a greater cardiovascular risk than unsaturated vegetable oils but is less harmful than animal-derived saturated fats, such as butter. A 2022 meta-analysis pooling data from 16 clinical studies found that palm oil raised LDL-C by 9.2% when compared to sunflower and canola oils, while it lowered LDL-C by 5.6% relative to butter consumption [41]. A clinical crossover study ($n = 96$) comparing palm oil, olive oil, and lard reported that palm oil induced a 7.8% increase in total cholesterol, while lard induced a 12.3% increase, and olive oil showed a 4.1% reduction [42]. These effects were consistent across male and female participants aged 25-60 years, with no significant sex-by-age interaction.

From a population health perspective, a cross-sectional study of 3,850 adults in Malaysia indicated that replacing soybean oil with palm oil over 5 years was associated with a 12.1% increase in metabolic syndrome prevalence ($p < 0.001$), even after adjusting for physical activity and BMI [43]. Conversely, two studies in rural Ghana found no significant association between palm oil intake and CVD biomarkers, possibly due to concurrent high-fibre, antioxidant-rich dietary patterns [44,45].

Population-Based Variability in Cardiovascular Outcomes

The physiological impact of palm oil varies by ethnicity, genetic background, and baseline diet. In Western cohorts (e.g., U.S. and Northern Europe), palm oil consumption was more consistently linked with elevated LDL-C and Carotid Intima-Media Thickness (CIMT), an early marker of atherosclerosis [46,47]. For example, a U.S.-based cohort study ($n = 4,512$) reported that individuals with high dietary saturated fat intake ($> 13\%$ TEI) had a 23% increased hazard ratio for progression of coronary artery calcification over a 5-year period [48]. In contrast, studies in Southeast Asia and Sub-Saharan Africa presented more mixed results. A study involving 3,200 participants from Indonesia and Nigeria showed that individuals with the APOE4 genotype had a 22% higher LDL-C response to high-palmitic-acid diets than non-carriers ($p < 0.05$) [49]. Socioeconomic and cultural factors also

played a role. In communities consuming unrefined red palm oil as part of traditional diets, the cardiovascular risk markers were notably lower compared to urban populations consuming refined, industrial palm oil [50,51].

Processing Methods, Oxidation, and Bioactive Compounds in Palm Oil

The health implications of palm oil are significantly influenced by processing and oxidation. Red palm oil, which retains carotenoids and tocotrienols, showed protective cardiovascular effects in 5 of 7 intervention studies, including reductions in total cholesterol (5.2%) and CRP (13%) after 8-week consumption [52,53]. In contrast, refined palm oil used for repeated frying led to detrimental outcomes. A 4-week trial on endothelial function found that daily consumption of thermally oxidized palm oil decreased flow-mediated dilation by 23% and increased serum oxidized LDL by 18% [54]. In rodent models, oil reused for frying increased hepatic malondialdehyde by 41% and plasma TNF- α by 36% compared to control oil [55,56].

Substitution and Dietary Contextualization of Palm Oil

The cardiometabolic outcomes of palm oil consumption depend heavily on the macronutrient it replaces. In 8 of the reviewed studies, replacing refined carbohydrates with palm oil led to favourable reductions in fasting glucose (5-7%), HOMA-IR scores (4-6%), and triglyceride/HDL ratios (6-9%) [57]. However, when PUFAs such as linoleic acid were replaced with palm oil, the effect was consistently negative. A controlled feeding study replacing 10% of energy from soybean oil with palm oil resulted in an 11.4% increase in LDL-C, a 9.8% increase in ApoB, and a 5.6% decrease in HDL-C ($p < 0.05$) [58]. These changes were accompanied by a 14% increase in IL-6, suggesting heightened systemic inflammation.

Public Health Policy and Risk Communication

The policy landscape surrounding palm oil is shaped by its economic and nutritional duality. According to FAO data, palm oil accounts for over 55% of cooking oil consumed in Indonesia and 48% in Nigeria [59]. For these countries, outright restriction of palm oil may have unintended nutritional and economic consequences. Leading public health institutions, such as WHO and AHA, maintain the recommendation that saturated fats should constitute less than 10% of overall caloric intake [60]. Labelling policies are one proposed intervention. A 2023 policy evaluation found that mandatory SFA labelling reduced population-wide saturated fat consumption by 7.2% within two years of implementation in Chile and 5.9% in Thailand [61]. In Southeast Asia, several studies advocated for the fortification of palm oil with tocopherols and polyphenols to counteract its pro-inflammatory effects. One pilot intervention involving fortified palm oil reduced LDL-C by 9.2% compared to conventional palm oil in a 12-week crossover study ($n = 142$) [62].

The 34 peer-reviewed, open-access articles included in this SLR demonstrate a nuanced and often context-dependent relationship

between palm oil consumption and cardiovascular risk. Most evidence suggests that palm oil increases LDL-C when compared to unsaturated oils, especially when it displaces PUFAs. However, this risk is modulated by factors such as processing methods, replacement nutrients, genetic variation, and coexisting dietary patterns. Important research gaps include a lack of long-term cohort studies in low-income regions, insufficient stratification by fatty acid subtype, and limited data on cumulative cardiovascular endpoints such as myocardial infarction or stroke incidence. Furthermore, more research is needed on cost-effective public health interventions that reconcile nutritional goals with socio-economic realities in palm oil-dependent regions. This evidence base, built from rigorously screened and thematically synthesized literature, offers a comprehensive and data-rich perspective on the cardiovascular implications of palm oil and saturated fats. These findings are expected to inform not only nutritional science but also policymaking, food industry reformulation, and future SLRs on dietary fat and chronic disease.

Discussion

To address the research question to what extent does the consumption of saturated fat from palm oil influence cardiovascular risk markers such as LDL-C, HDL-C, triglycerides, and inflammatory indicators, based on recent peer-reviewed evidence? this discussion synthesizes findings from peer-reviewed studies published between 2021 and 2025 using a Systematic Literature Review (SLR) approach. The evidence suggests that the cardiovascular impact of palm oil varies significantly depending on the biomarker assessed, the processing form of the oil (refined vs. red), population characteristics, and comparative dietary context.

Effects on LDL-C (Low-Density Lipoprotein Cholesterol)

The majority of recent Randomized Controlled Trials (RCTs) consistently report that palm oil consumption leads to an increase in LDL-C compared to unsaturated oils such as olive, soybean, or sunflower oils [63,64]. For instance, a 2022 meta-analysis of 17 RCTs involving over 1,200 participants revealed that substituting palm oil for monounsaturated fat led to an average LDL-C increase of 8-12% over six weeks [65]. However, this increase was notably smaller than that caused by trans fats, suggesting a relatively lesser atherogenic potential [66]. It is also worth noting that the effect size on LDL-C appears influenced by baseline lipid status. Participants with normal baseline cholesterol levels exhibited milder LDL-C elevation, while those with pre-existing dyslipidaemia showed more significant increases [67]. Furthermore, the chain length of the saturated fatty acids in palm oil predominantly palmitic acid has been shown to impact lipoprotein metabolism differently than shorter-chain saturated fats [68].

Effects on HDL-C (High-Density Lipoprotein Cholesterol)

The impact of palm oil on HDL-C is more heterogeneous. Some studies report a modest increase in HDL-C levels following palm oil consumption, particularly when compared to trans fats or

high-carbohydrate diets [69,70]. A cross-sectional study involving Southeast Asian populations consuming palm oil as a staple found that HDL-C levels were approximately 5-7% higher in palm oil users compared to those consuming partially hydrogenated fats [71]. However, when compared to unsaturated oils, palm oil generally produced lower HDL-C levels [72]. Notably, the beneficial HDL-C response is more prominent when red palm oil is used, due to its antioxidant content, such as tocotrienols and carotenoids. These bioactive compounds may contribute to improved reverse cholesterol transport, though more longitudinal data are required to validate this hypothesis [73].

Effects on Triglycerides (TG)

Palm oil's impact on triglyceride levels tends to be neutral or marginally positive. A multicentre dietary intervention involving 680 individuals from three continents demonstrated no statistically significant difference in fasting triglyceride concentrations between palm oil and sunflower oil groups over an eight-week period [74]. However, in populations with diets high in refined carbohydrates, replacing carbohydrate calories with palm oil appeared to modestly reduce triglyceride levels by 5-10% [75]. This aligns with previous findings suggesting that dietary carbohydrate has a more potent effect on TG elevation than saturated fat. Red palm oil again emerges as potentially more favourable. The same study reported that participants consuming red palm oil had lower postprandial triglyceride responses, possibly due to improved lipid oxidation influenced by antioxidant compounds [76]. These findings, however, require confirmation through larger trials with uniform dosing and duration.

Effects on Inflammatory Markers

The role of palm oil in modulating systemic inflammation remains inconclusive. High saturated fat intake has been associated with increased inflammatory biomarker levels, such as CRP, IL-6, and TNF- α , as demonstrated in various interventional trials, including palm oil [77]. Yet, these elevations often occurred in the context of hypercaloric diets or when palm oil was consumed with ultra-processed foods. In contrast, studies isolating palm oil within balanced diets found no significant pro-inflammatory effects. One RCT conducted in Malaysia found no significant changes in CRP and IL-6 levels after 12 weeks of palm oil consumption when calorie intake was controlled [78]. Furthermore, red palm oil exhibited anti-inflammatory properties in rodent models, attributed to its antioxidant components. However, human data remain limited and inconsistent, necessitating further investigation.

Contextual Factors: Processing, Diet Pattern, and Socioeconomic Influences

A recurring theme in the literature is the influence of contextual factors. The degree of processing significantly affects the lipid and inflammatory responses to palm oil. Refined palm oil lacks the micronutrients found in red palm oil, which may modulate oxidative stress and inflammation [79]. Additionally, the background diet is

a major determinant of health outcomes. Palm oil replacing trans fats or refined carbohydrates generally results in improved lipid profiles, while its substitution for unsaturated fats tends to worsen them. Moreover, socioeconomic status influences dietary patterns, with populations in lower-income countries often relying on palm oil as a primary energy source due to affordability. This dependence can exacerbate health risks if accompanied by low intake of fruits, vegetables, and physical inactivity [80].

Synthesizing the Evidence: Nuanced Health Impacts

The evidence underscores the complexity of assessing palm oil's cardiovascular effects. While palm oil is not benign, its impact is context-dependent. The consumption of palm oil leads to mild increases in LDL-C and modest reductions in HDL-C relative to unsaturated fats, but shows better profiles compared to trans fats or high-carbohydrate alternatives. Triglyceride and inflammation responses are largely modulated by total diet quality and energy balance [81]. This nuanced profile suggests that blanket recommendations to eliminate palm oil may be misguided in certain populations, especially in low- and middle-income countries where nutritional options are limited. Rather, dietary policies should consider the broader context, including alternative oil availability, economic access, and prevailing health behaviours. This review provides a critical synthesis of the recent evidence on the cardiovascular impact of palm oil consumption. It suggests that while palm oil contributes to modest elevations in cardiovascular risk markers, particularly LDL-C, the magnitude and significance of these effects vary based on comparison oils, dietary context, and oil processing methods.

The findings imply that dietary recommendations should move beyond binary categorizations of fats as "good" or "bad" and embrace a more contextualized approach. Health authorities might consider differentiating between refined and red palm oil, emphasizing moderation, and promoting dietary diversity rather than outright avoidance. Advancing the evidence base will require future research to emphasize robust, long-term cohort studies that integrate detailed nutritional tracking and biomarker profiling to clarify the direct relationship between palm oil consumption and actual cardiovascular events. Additionally, more studies are needed in diverse populations, especially in regions where palm oil constitutes a major dietary staple. Ultimately, evidence-based dietary guidelines should align scientific findings with socioeconomic realities to support both public health and nutritional equity.

Conclusion

Analysis of recent peer-reviewed studies (2021-2025) indicates that the link between saturated fats from palm oil and cardiovascular biomarkers is multifaceted rather than straightforward. Elevated Low-Density Lipoprotein Cholesterol (LDL-C) was consistently observed in studies where palm oil replaced polyunsaturated fats, although the magnitude of increase varied depending on the

dosage, duration, and baseline dietary pattern. Notably, when palm oil replaced trans fats or excessive refined carbohydrates, a neutral or even modestly favourable effect on lipid profiles was reported in several trials. Following moderate palm oil consumption, levels of HDL cholesterol generally exhibited no significant change or experienced a slight rise, particularly in trials utilizing unrefined red palm oil rich in tocotrienols and carotenoids. Some data even suggest a modest HDL-C-raising effect when palm oil was consumed as part of a balanced diet. Meanwhile, triglyceride responses were heterogeneous; while some studies documented modest increases, others found reductions, especially when palm oil replaced high-glycemic-index carbohydrates or hydrogenated oils. Findings regarding inflammatory indicators such as CRP and IL-6 demonstrated notable variability across the reviewed literature. A subset of trials indicated a pro-inflammatory response to high saturated fat intake, yet others reported no significant change or slight anti-inflammatory effects when red palm oil was used or when overall diet quality was controlled. This suggests that inflammatory outcomes are highly context-dependent, influenced by total dietary composition, antioxidant intake, and metabolic status of the population studied.

The reviewed evidence indicates that the health effects of palm oil cannot be assessed in isolation from broader dietary and lifestyle patterns. Contextual variables such as oil processing methods, background diet, comparison fat types, and population risk profiles strongly mediate outcomes. Not all saturated fats are metabolically equivalent, and palmitic acid though often implicated in lipid elevation demonstrates variable effects depending on the food matrix and co-nutrient interactions. Taken together, the findings call for a more differentiated dietary policy regarding palm oil. While caution is warranted in recommending high intakes of refined palm oil, especially in populations at elevated cardiovascular risk, moderate consumption particularly of unrefined red palm oil in the context of an overall healthful diet may not carry the same risk as once presumed. These insights align with growing challenges to traditional saturated fat guidelines and highlight the importance of updating dietary recommendations based on recent and population-specific evidence. The present review affirms that saturated fat from palm oil does influence cardiovascular biomarkers, but not uniformly or predictably. LDL-C elevations are modest and context-dependent, HDL-C may be maintained or improved, triglyceride changes are mixed, and inflammatory effects are inconclusive but not uniformly adverse. Scientific consensus requires greater precision than categorical exclusion, and further rigorous, long-term, and population-specific studies are needed to better guide policy and public health messaging.

Conflict of Interest

None.

Acknowledgement

None.

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