PU5922 MSc Research Project
Academic Paper Cover Page

Student ID Number: 52215310

Title: The effect of coconut oil consumption on cardiometabolic health in adults: a systematic review

Total Word Count: 2625 words

Referencing Style: Vancouver referencing style

Declaration of the generated material

I acknowledge the use of ChatGPT (https://chatgpt.com) to enhance content that I have created. The prompts used include improving tone and grammar. The output from these prompts was then modified my writing.

Abstract

Background: Coconut oil is not a widely recommended oil for cholesterol health compared to other vegetables oils because of its high level of saturated fatty acids. However, some recent evidence suggests beneficial effect of coconut oil on cardiometabolic health. We conducted a systematic review to present current evidence on the effect of coconut oil on cardiometabolic health. **Methods:** Databases including Medline, Embase, the Cochrane Library and PubMed were searched for articles published from 2008 to June 2024. We selected trials that compared the effect of coconut oil intake with other types of fat or normal dietary care. The main outcomes included lipid profiles, markers of inflammation, glycemic control, anthropometric measurements, and blood pressure. **Results:** There are 734 citations retrieved from the search. After removing of duplicates and screening title and abstract, 16 articles met all inclusion criteria and underwent critical appraisal. Coconut oil consumption had no significant effect the glycated haemoglobin levels, C-reactive protein levels, waist-to-hip ratio, or waist circumference, nor did it influence blood pressure. However, coconut oil significantly increased high-density lipoprotein cholesterol compared to other vegetable oils while its effect on low-density lipoprotein cholesterol remains inconclusive. **Conclusion:** There is little evidence to support the superiority of coconut oil over other vegetable oils like olive oil, soybean oil, palm oil, sunflower oil, and safflower oil in improving cardiometabolic health. However, there is no conclusive evidence suggesting that coconut oil has a harmful effect on cardiometabolic health.

1. Introduction:

Cardiovascular diseases (CVDs) are the leading cause of death, responsible for approximately 17.9 million deaths each year [1]. While CVDs can step from multiple factors, unhealthy diet is well-known recognized as a significant contributing risk factor. The effect of dietary fats on CVDs has been debated. Many studies have been performed to clarify the link between saturated fat and CVDs, but the results are still inconsistent. Hooper et al. [2] in his study reported that reducing saturated fat intake might potentially reduce a combined cardiovascular event. Similarly, Clifton et al. [3] suggest that replacing saturated fat with unsaturated fat might reduce the incidence of cardiovascular diseases.

In contrast, Dinicolantonio et al. [4] implicated refined sugars more than saturated fatty acids (SFAs) as etiological factors in CVDs. Chowdhury et al. [5] indicated that there was no significant association between dietary saturated fat and cardiovascular risks.

Coconut oil (CO) has unique characteristics because it contains high level of lauric acid, which is a type of medium-chain triglyceride (MCT) [7]. Unlike long-chain triglycerides, MCTs can be rapidly metabolized in the body, providing an immediate source of energy by going straight to the liver where they can be converted into ketones [8]. The kind of SFAs in coconut oil differ from those found in other sources such as butter or animal fat.

Coconut oil is not a widely recommended oil for cholesterol health compared to other vegetable oils due to its high level of saturated fat, which can increase low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC) and triglycerides (TG). Teng et al. [9] reported that coconut oil might raise levels of low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C), in comparison with other vegetable oils. Neelankanta et al. [10] reported in their study that no evidence of benefits of coconut oil for weight loss, glycemic control, or improving inflammatory markers, compared to other plant oils. Conversely, some recent studies have suggested favorable effects of coconut oil intake on cardiovascular heath [11-14]. We aim to gather other recent clinical trials to provide up-to-date evidence on the effect of coconut oil on cardiometabolic health.

2. Methods:

2.1 Sources.

We searched in four databases, including Medline, Embase, the Cochrane Library and PubMed from 2008 to June 2024. Our search strategy followed a three-step approach. Firstly, we performed a manual search of MEDLINE to identify all potential keywords relevant to the topic. Secondly, we conducted a comprehensive search using all keywords and relevant terms across all four databases. Finally, we reviewed the reference list for any relevant articles.

Search term: (cocos* OR "coconut oil*") AND ("cardiovascular diseases*" OR lipid* OR "heart diseases*" OR cholesterols*).

2.2 Study selection

The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [15].

Studies will be eligible if they are clinical trials that investigated the effect of coconut oil (or virgin coconut oil [VCO]) intake compared to placebo, normal dietary care or plant oils. Selected trials had an intervention period of more than 2 weeks to allow blood samples to stabilize [16]. Studies reporting health outcomes related to cardiometabolic health including blood cholesterol, blood pressure, glycaemic control, anthropometric measures, or inflammatory markers will be assessed.

The studies were excluded if they involved participants as infants, had follow-ups shorter than 2 weeks, or had small sample size of fewer than 20 (due to concerns about statistical significance). Studies using inappropriate interventions (fresh coconut, coconut milk) or inappropriate comparators (carboxymethyl cellulose) as well as the studies with irrelevant health outcomes (Alzheimer, oral health, sclerosis, depression, dermatitis) were also excluded. Finally, studies were implemented before 2008 were excluded, which allows this systematic review to focus on most recent and relevant

evidence. It also helps to narrow down the volume of literature, which makes the process more efficient.

2.3 Quality assessment:

The quality assessment of the included trials was conducted using Jadad scale [17], which assesses whether they have randomization, a valid description of randomization method, double-blinding, a valid description of double-blinding, and proper handling of withdrawals and dropouts. Each item is awarded as one point with the total score ranged from 0 (poor quality) to 5 (high quality).

2.4 Data Extraction:

The data extraction protocol included the following information: numbers of participants, study duration, interventions administrated, comparator used, participant's disease status, study outcomes. Data extraction focused on assessing the effects of coconut oil on lipid markers (LDL-C, HDL-C, TC, TG), glycaemic controls (glycated haemoglobin [HbA1c]), inflammatory markers (C-reactive protein), anthropometric profiles (body mass index [BMI], waist circumference [WC] and waist-to-hip ratio [WTH], and blood pressure (systolic blood pressure [SBP] and diastolic blood pressure [DBP] or ankle brachial index [ABI]).

3. Results:

Database searches initially retrieved a total of 734 citations. After removing of duplicates and screening title and abstract, 16 articles met all inclusion criteria and underwent critical appraisal. These 16 articles were included for data extraction, synthesis, and analysis (Figure 1).

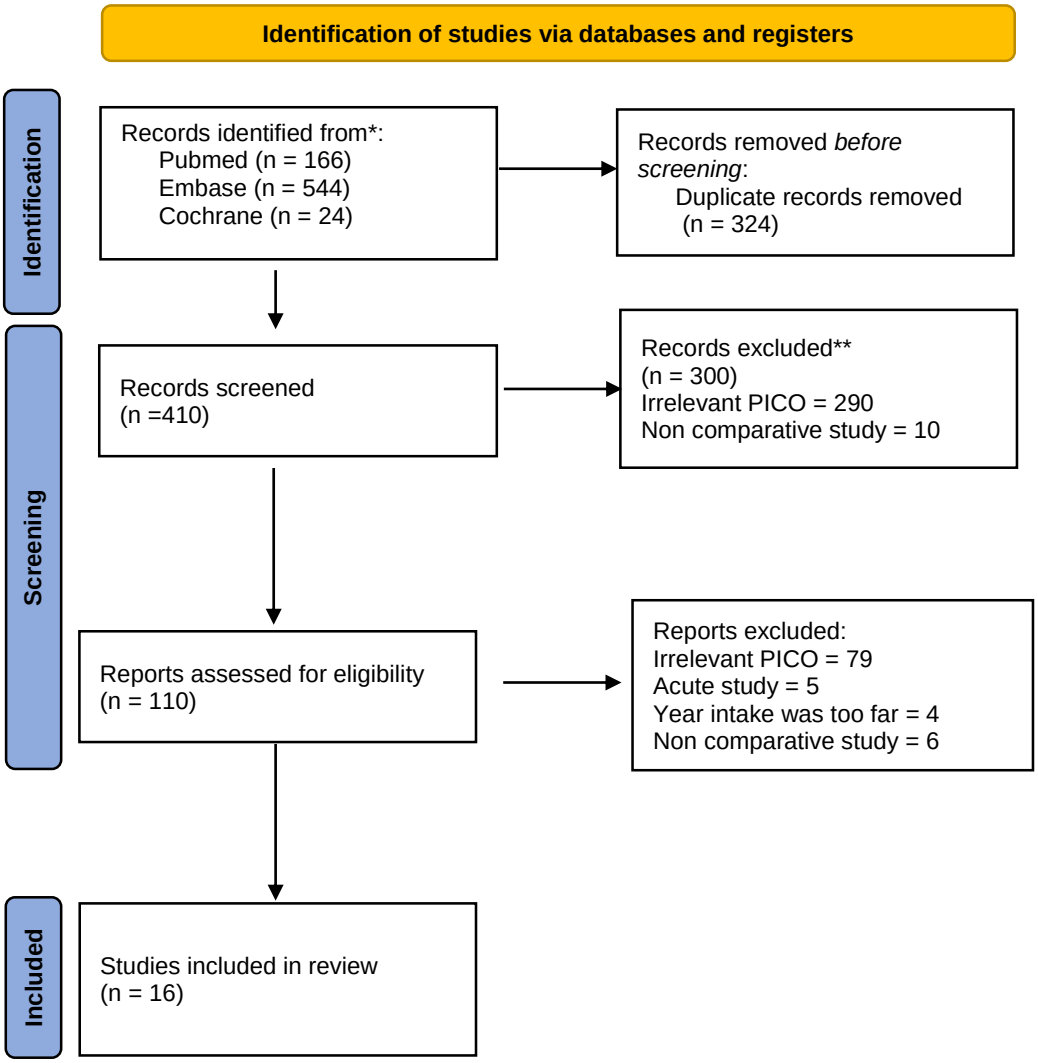

Figure 1: PRISMA (preferred reporting items for systematic reviews and meta-analysis) flowchart

The included studies were conducted in seven different countries, with follow-ups duration ranging from two weeks to two years. In five trials, coconut oil was compared to normal diet or placebo or to monounsaturated fatty acids (MUFAs) such as olive oil [11,18,19,20,21]. Two studies compared coconut oil to saturated fatty acids (SFAs) such as butter or palm oil [13,22] while eleven studies compared coconut oil to polyunsaturated fatty acids (PUFAs) from sources such as soybean, chia, safflower, sunflower, and corn [12,13,14,22,23,24,25,26,27,28,29].

Five studies included healthy individuals [13,22,24,25,26]; six studies included subjects with abdominal obesity, overweight, or obesity [12,14,18,23,27,28]; one study involved postmenopausal

women [29]; one study focused on patients with diabetes mellitus [11], one on individuals with dyslipidemia [21], and one on participants with coronary artery disease. The key features of all selected studies are presented in Table 1.

Five studies were graded as high quality [14,21,24,27,28], eights studies as moderate [11,12,13,20,22,23,26,29], and three studies as low quality [18,19,25] (Figure 2).

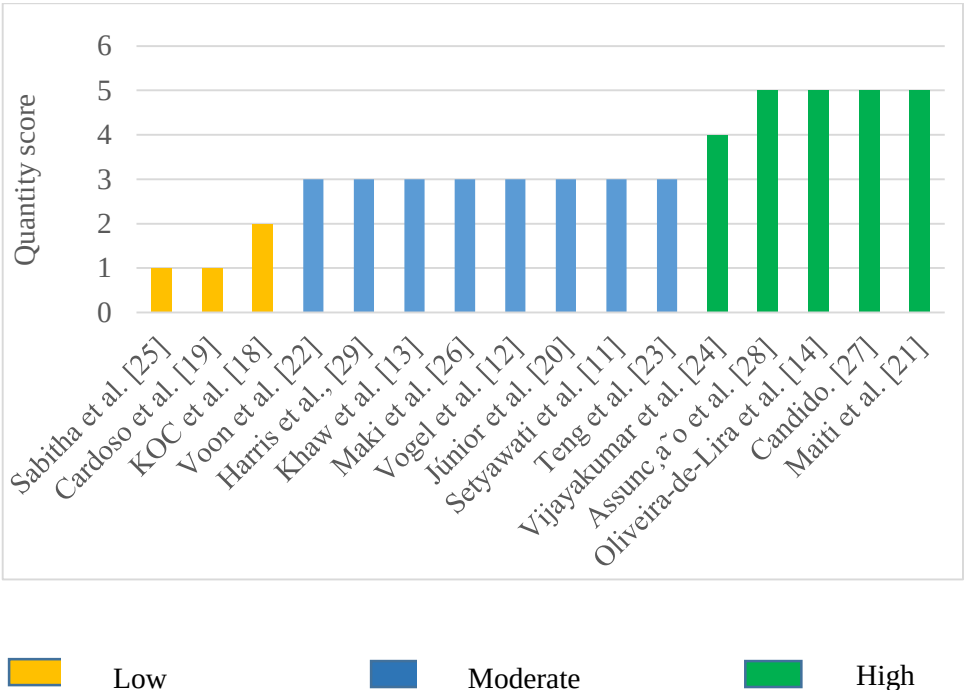

Figure 2: Quality scores of papers included for review.

Table 1: Characteristics of studies included in the systematic review

No	Use	Study	Country	Administration	Subjects	Comparators	Duration	Outcomes	No of subjects
1	VCO	Setyawati et al. [11] 2023	Indonesia	1.2 mL/kgBW of VCO daily	Diabetes Mellitus	Diet	30 days	TC, TG, LDL, HDL, ABI level	136
2	CO	Vogel et al. [12] 2020	Brasil	12 ml per day	Obesity	Soybean oil	45 days	BMI, WC, WTH, TC, TG, LDL, HDL, Glycaemic control	29
3	CO	Khaw et al. [13] 2018	The UK	50 g per day	Healthy	butter or extra virgin olive oil,	4 weeks	BMI, WC, WTH, TC, TG, LDL, HDL, C-reactive protein	94
4	VCO	Oliveira-de-Lira et al. [14] 2018	Brasil	6g per day	Obese Women	Chia seed, safflower seed, soybean oil	8 weeks	Weight loss, TC, TG, LDL, HDL, Glycaemic Control	75
5	CO	KOC et al. [18] 2022	Turkey	20 ml per day	overweight individuals	Diet therapy	10 weeks	BMI, Glycaemic control, TC, TG, LDL, HDL	44
6	VCO	Cardoso et al. [19] 2015	Brasil	13ml per day	coronary artery disease patients	Diet	6 months	BMI, TC, TG, LDL, HDL, Blood pressure, Glycaemic Control	114
7	CO	Júnior et al. [20] 2021	Brasil	10ml per day	Hypertensive Patients	Placebo	30 days	Blood pressure	51
8	VCO	Maiti et al. [21] 2023	India	1 gram per meal	Patients with Dyslipidemia	Placebo	8 weeks	TC, TG, LDL, HDL	150

9	CO	Voon et al. [22] 2011	Malaysia	20% calories through meals	Healthy adults	palm oil and olive oil	5 weeks	TC, TG, LDL, HDL, C-reactive protein	45
10	VCO	Teng et al. [23] 2023	Malaysia	20% enegy fat of the meal	individuals with central obesity	red palm olein and extra virgin olive oil	12 weeks	TC, TG, LDL, HDL, C-reactive protein	143
11	CO	Vijayakumar et al. [24] 2015	India	Cooking medium	Healthy adults	Sunflower oil	2 years	BMI, WTH, Lipid profile, HbA1c	200
12	CO	Sabitha et al. [25] 2009	India	Cooking medium	Healthy men	Sunflower oil	6 years	TC, TG, LDL, HDL	140
13	CO	Maki et al. [26] 2018	The United States	54g though meals	Healthy adults	Corn oil	4 weeks	TC, TG, LDL, HDL, C-reactive protein	24
14	CO	Candido et al. [27] 2020	Brasil	25 ml per day	overweight women	EVOO, Soybean oil	9 weeks	TC, TG, LDL, HDL	61
15	CO	Assunc¸a˜o et al. [28] 2009	Brasil	30 ml per day	Women Presenting Abdominal Obesity	Soybean oil	12 weeks	BMI, WC, TC, TG, LDL, HDL, C-reactive protein, glycaemic control	40
16	VCO	Harris et al. [29] 2017	The United States	30 mL daily through meals	Postmenopausal Women	safflower oil	4 weeks	BMI, WC, WTH, TC, TG, LDL, HDL	28

Fifteen studies analysed the effects of coconut oil intake on lipids profiles including TC, TG, HDL-C and LDL-C, with a total of 1374 participants. In three trials comparing coconut oil with normal diet, two studies [11,19] indicated that coconut oil resulted in an increase in HDL-C levels, while only one study [18] showed no difference between groups. In eleven trials comparing coconut with other vegetable oils, two studies of high quality [14,28] and five studies of moderate quality [12,13,22,26,29] reported that coconut oil resulted in significantly higher level of HDL-C; conversely, two studies of high-quality [24,27] and one study of moderate quality [23] indicated that coconut oil did not show any significant difference between comparators.

Four studies of moderate quality [13,22,23,29] showed that coconut oil raised LDL-C, whereas one study of high quality [28] indicated that coconut oil resulted in favourable LDL-C levels compared to soybean oil. Conversely, five studies [12,24,25,26,27] reported that there was no significant difference in LDL-C levels after interventions. Among three studies comparing coconut oil with normal diet, one moderate-quality study [11] showed a reduction in LDL-C levels with coconut oil intake.

Seven studies [18,19,22,24,25,26,27] indicated that there were no significant differences in TC/HDL-C or TG/HDL-C ratios between coconut oil and comparators. However, notably, one study of high quality [14] and two studies of moderate quality [12,29] reported an improvement in lipid profiles with reduction in TC/HDL-C or TG/HDL-C ratios in groups that consumed coconut oil.

Eight different studies reported the effect of coconut oil on BMI, WC or WHR, with a total of 628 participants. Four studies including one study of high quality [24] and three studies of moderate quality [12,13,29] found no significant differences in anthropometric measurements when comparing coconut oil with other vegetable oils. In contrast, two high-quality studies indicated that coconut oil consumption significantly reduced the WC [14,28].

Seven different studies reported on the effect of coconut oil intake on glycemic control parameters including plasma glucose response, insulin levels or HbA1c levels, with a total of 596 participants. One high-quality study [14] reported that coconut oil consumption resulted in an improvement in glycemic parameters. However, two studies of high quality [24,28] and two studies of moderate quality [12,13] indicated that there were no significant differences in glycemic control between coconut oil and comparators.

Seven different studies examined the effect of coconut oil on C-reactive protein levels. Two studies of high quality [24,28] and three studies of moderate quality [22,23,26] indicated that there were no significant differences between coconut oil and other plant oils such as olive oil, soybean oil or corn oil. In contrast, one study of moderate quality [13] reported that coconut oil intake decreased C-reactive protein levels compared to olive oil.

Three studies investigated the effect of coconut oil intake on blood pressure. Two studies focused on diastolic blood pressure while the third study explored the effect of coconut oil on ABI, which compares the blood pressure in the upper and lower limbs.

4. Discussion:

This systematic review indicates that compared to other types of oils, coconut oil does not demonstrate superiority in reducing body weight or altering body mass. This finding is consistent with the study of Swarnamali et al. [30], which indicated that the consumption of coconut oil did not result in statistically significant changes in WC, WHR, or fat mass. However, it has been noted that some high-quality evidence suggests that coconut oil consumption can significantly reduce WC [14,28]. This reduction is potentially due to its roles in supporting weight loss by reducing calories intake [31]. Another animal study demonstrated that mice experienced significantly higher weight loss with coconut intake compared to the control group [32]. Given that coconut oil contains 65% medium-chain triglyceride, it may process fat-burning properties like pure MCT oil [33].

Glycemic control plays a crucial role in cardiovascular diseases. Intensive therapy for glycemic control reduced the risk of major cardiac events by 9%, nonfatal myocardial infarction by 15%

[34] and CVD by 10% [35]. In this systematic review, the majority of evidence indicates that coconut oil provides no benefit for glycemic control compared to other vegetable oils [12,13,24,28].

Plasma levels of inflammatory markers such as C-reactive protein have been shown to be predictive markers for assessing cardiovascular risk [36]. In this systematic review, most of evidence did not demonstrate any significant difference in improving inflammatory markers between coconut oil and comparators. However, one study indicated coconut oil might be potentially effective in reducing C-reactive protein levels [13]. This observation is consistent with an intervention trial that reported a decline in C-reactive protein levels with coconut oil consumption [37]. We also identified several animal studies demonstrating potential anti-inflammatory effect of coconut oil. Dietary virgin coconut oil might suppress inflammatory mediators and oxidative stress [38]. Additionally, virgin coconut oil has been suggested as beneficial in chemotherapy by lowering oxidative stress and pro-inflammatory responses [39].

Large cohort studies have demonstrated that high blood pressure is a significant risk factor for cardiovascular disease [40]. Animal experiments suggested a protective effect of coconut oil [41,42]. However, this systematic review indicates that there is no significant difference in blood pressure between coconut oil and comparators. Only one study of low quality [19] reported a reduction in blood pressure with the consumption of extra virgin coconut oil.

Regarding lipid profiles, it is well acknowledged that coconut oil consumption can raise HDL-C level. These findings align with the evidence from Mensink et al. [43], indicating that lauric acid, a type of fat in coconut oil, can significantly increase HDL-C, compared to PUFAs or MUFAs. Several epidemiological studies demonstrate the protective effect of HDL-C in reducing the incidence of coronary heart disease [44,45,46]. Conversely, a low level of HDL-C is strong predictor of cardiovascular diseases [47].

Regarding LDL-C, the results from the included studies on the effect of coconut oil consumption have been inconclusive. However, Setyawati et al. [11] in their recent study found that virgin coconut oil significantly reduced in TC, TG and LDL-C levels. This contrasts with several systematic reviews

that reported a significant increase in LDL-C with coconut oil intake compared to other plant oils [9,10,48]. It is worth noting that two studies [23,24] which used coconut oil as cooking medium for two and six years respectively, showed no statistically significant differences in either LDL-C or HDL-C.

Regarding total cholesterol levels, the collected evidence agrees that coconut oil does not show any differences in TC/HDL-C or TG/HDL-C ratios compared to other oils used as comparators. Similarly, Eyres et al. [49] in their systematic review, did not find any negative effect of coconut oil intake on the lipid profiles.

Notably, a systematic review by Teng et al. [8] reported that standard coconut oil significantly increased LDL-C levels, while virgin coconut oil showed no effect on LDL-C levels. There is various evidence suggesting that industrial seed oils can stimulate oxidative stress and oxidised LDL-C levels [50]. This systematic review was unable to clarify what processed form of vegetable oils used in these interventions. Only six studies examined the effect of virgin coconut oil [11,14,19,21,23,29] while four studies clearly indicated the forms of comparators, which were extra virgin olive oil [13,22,23,27]. A recent study by Ekanayaka et al. [51] confirmed that different coconut preparations resulted in different effect on lipid profiles. The protective effects of virgin coconut oil may be attributed to the presence of MCT oil and high levels of antioxidant polyphenols [52].

LDL-C concentration is a primary target for cardiovascular protection. However, the PREDIMED study [53] indicated that Mediterranean diet with extra virgin olive oil resulted in a significant reduction in TC/HDL-C ratio but no difference in LDL levels. We observed a similar effect with coconut oil intake as indicated in this review, showing a significant decrease in the TC/HDL-C ratio [12,14,29]. Ravnskov et al. [54] in their study, indicated that LDL-C levels was not associated with the risk of dying from cardiovascular diseases. On the other hand, Loganathan et al. [55] in randomized control study reported that small, dense LDL-C particles, not large, buoyant LDL particles are associated cardiovascular diseases, suggesting complex relationship between LDL-C

particle size and cardiovascular risks. Notably, in the most recent trial by Teng et al. [23] investigating cholesterol subfractions, in the comparison between extra virgin olive oil, red palm olein and extra virgin coconut oil, there was no difference LDL-C and HDL-C subfractions, with mostly large, buoyant LDL particles found across three diets.

There are limitations in our systematic review. Firstly, the quality of our systematic review depends on the quality of the studies included. We observed that several clinical trials included had a low-quality design, such as lacking blinding or randomization, which might introduce biases into our results. To mitigate the bias, we assigned greater weight to evidence from moderate and high-quality studies. Secondly, our systematic review focused on investigating the risk factors of cardiovascular diseases rather than cardiovascular events. To the best of our knowledge, there are no interventions investigating the effect of coconut oil on cardiovascular events due to high cost and the need for long-term follow up. Therefore, this limitation cannot be addressed. Thirdly, interventions included in our review vary substantially in terms of sample size, comparators used, subject' status, follow-up duration, dose of coconut oil administered, and forms of coconut oil (virgin or standard). This heterogeneity in study designs may potentially affect the generalizability and consistency of our findings.

In conclusion, there is little evidence to support the superiority of coconut oil over other vegetable oils like olive oil, soybean oil, palm oil, sunflower oil, and safflower oil in improving cardiometabolic health. Furthermore, current recommendations do not favour the use of coconut oil due to its potential risk in cardiovascular diseases; however, there is no conclusive evidence suggesting that coconut oil has a harmful effect on cardiometabolic health. Further research is needed to better understand the effect of coconut oil consumption in relation to cardiometabolic diseases.

References

[1] World Health Organization. Cardiovascular diseases. World Health Organization website. Available from: https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1. Accessed July 11, 2024.

[2] Hooper L, Martin N, Jimoh OF, Kirk C, Foster E, Abdelhamid AS. Reduction in saturated fat intake for cardiovascular disease. Cochrane Database Syst Rev 2020 Aug 21;8(8):CD011737.

[3] Clifton PM, Keogh JB. A systematic review of the effect of dietary saturated and polyunsaturated fat on heart disease. Nutr Metab Cardiovasc Dis 2017 Dec;27(12):1060-1080.

[4] DiNicolantonio JJ, Lucan SC, O'Keefe JH. The Evidence for Saturated Fat and for Sugar Related to Coronary Heart Disease. Prog Cardiovasc Dis 2016;58(5):464-472.

[5] Chowdhury R, Warnakula S, Kunutsor S, Crowe F, Ward HA, Johnson L, et al. Association of dietary, circulating, and supplement fatty acids with coronary risk: a systematic review and meta-analysis. Ann Intern Med 2014 Mar 18;160(6):398-406.

[6] Givens DI. Saturated fats, dairy foods and cardiovascular health: No longer a curious paradox? Nutr Bull 2022 Dec;47(4):407-422.

[7] Boateng L, Ansong R, Owusu WB, Steiner-Asiedu M. Coconut oil and palm oil's role in nutrition, health and national development: A review. Ghana Med J 2016 Sep;50(3):189-196.

[8] Wang Y, Liu Z, Han Y, Xu J, Huang W, Li Z. Medium Chain Triglycerides enhances exercise endurance through the increased mitochondrial biogenesis and metabolism. PLoS One 2018 Feb 8;13(2):e0191182.

[9] Teng M, Zhao YJ, Khoo AL, Yeo TC, Yong QW, Lim BP. Impact of coconut oil consumption on cardiovascular health: a systematic review and meta-analysis. Nutr Rev 2020 Mar 1;78(3):249-259.

[10] Neelakantan N, Seah JYH, van Dam RM. The Effect of Coconut Oil Consumption on Cardiovascular Risk Factors: A Systematic Review and Meta-Analysis of Clinical Trials. Circulation 2020 Mar 10;141(10):803-814.

[11] Setyawati A, Sangkala MS, Malasari S, Jafar N, Sjattar EL, Syahrul S, et al. Virgin Coconut Oil: A Dietary Intervention for Dyslipidaemia in Patients with Diabetes Mellitus. Nutrients 2023 Jan 21;15(3):564. doi: 10.3390/nu15030564.

[12] Vogel CÉ, Crovesy L, Rosado EL, Soares-Mota M. Effect of coconut oil on weight loss and metabolic parameters in men with obesity: a randomized controlled clinical trial. Food Funct 2020 Jul 1;11(7):6588-6594.

[13] Khaw K, Sharp SJ, Finikarides L, Afzal I, Lentjes M, Luben R, et al. Randomised trial of coconut oil, olive oil or butter on blood lipids and other cardiovascular risk factors in healthy men and women. BMJ Open 2018 Mar 6;8(3):e020167-020167.

[14] Oliveira-de-Lira L, Santos EMC, de Souza RF, Matos RJB, Silva MCd, Oliveira LDS, et al. Supplementation-Dependent Effects of Vegetable Oils with Varying Fatty Acid Compositions on Anthropometric and Biochemical Parameters in Obese Women. Nutrients 2018 Jul 20;10(7):932. doi: 10.3390/nu10070932.

[15] Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009 Jul 21;6(7):e1000097.

[16] SPRITZ N, AHRENS EHJ, GRUNDY S. Sterol Balance in Man as Plasma Cholesterol Concentrations are Altered by Exchanges of Dietary Fats. J Clin Invest 1965 Sep;44(9):1482-1493.

[17] Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials 1996 Feb;17(1):1-12.

[18] Meral Koc B, Yilmaz Akyuz E, Ozlu T. The effect of coconut oil on anthropometric measurements and irisin levels in overweight individuals. Int J Obes (Lond) 2022 Oct;46(10):1735-1741.

[19] Cardoso DA, Moreira ASB, de Oliveira GMM, Raggio Luiz R, Rosa G. A Coconut Extra Virgin Oil-Rich Diet Increases Hdl Cholesterol and Decreases Waist Circumference and Body Mass in Coronary Artery Disease Patients. Nutr Hosp 2015 Nov 1;32(5):2144-2152.

[20] Júnior FAO, Ruiz CR, de Oliveira Y, Barros MAV, Silva AS, Santos MSB, et al. Coconut Oil Supplementation Does Not Affect Blood Pressure Variability and Oxidative Stress: A Placebo-Controlled Clinical Study in Stage-1 Hypertensive Patients. Nutrients 2021 Feb 28;13(3):798. doi: 10.3390/nu13030798.

[21] Maiti R, Mohanty RR, Dey A, Maji S, Padhan M, Mishra A. Effect of Virgin Coconut Oil (VCO) on Cardiometabolic Parameters in Patients with Dyslipidemia: A Randomized, Add-on Placebo-Controlled Clinical Trial. J Am Nutr Assoc 2024;43(3):244-251.

[22] Voon PT, Ng TKW, Lee VKM, Nesaretnam K. Diets high in palmitic acid (16:0), lauric and myristic acids (12:0 + 14:0), or oleic acid (18:1) do not alter postprandial or fasting plasma homocysteine and inflammatory markers in healthy Malaysian adults. Am J Clin Nutr 2011 Dec;94(6):1451-1457.

[23] Teng K, Loganathan R, Chew BH, Khang TF. Diverse impacts of red palm olein, extra virgin coconut oil and extra virgin olive oil on cardiometabolic risk markers in individuals with central obesity: a randomised trial. Eur J Nutr 2024 Jun;63(4):1225-1239.

[24] Vijayakumar M, Vasudevan DM, Sundaram KR, Krishnan S, Vaidyanathan K, Nandakumar S, et al. A randomized study of coconut oil versus sunflower oil on cardiovascular risk factors in patients with stable coronary heart disease. Indian Heart J 2016;68(4):498-506.

[25] Sabitha P, Vaidyanathan K, Vasudevan DM, Kamath P. Comparison of lipid profile and antioxidant enzymes among south Indian men consuming coconut oil and sunflower oil. Indian J Clin Biochem 2009 Jan;24(1):76-81.

[26] Maki KC, Hasse W, Dicklin MR, Bell M, Buggia MA, Cassens ME, et al. Corn Oil Lowers Plasma Cholesterol Compared with Coconut Oil in Adults with Above-Desirable Levels of Cholesterol in a Randomized Crossover Trial. J Nutr 2018 Oct 1;148(10):1556-1563.

[27] Netto Cândido TL, da Silva LE, Cândido FG, Valente FX, da Silva JS, Gomes Lopes DR, et al. Effect of the ingestion of vegetable oils associated with energy-restricted normofat diet on intestinal microbiota and permeability in overweight women. Food Res Int 2021 Jan;139:109951.

[28] Assunção ML, Ferreira HS, dos Santos AF, Cabral CRJ, Florêncio TMMT. Effects of dietary coconut oil on the biochemical and anthropometric profiles of women presenting abdominal obesity. Lipids 2009 Jul;44(7):593-601.

[29] Harris M, Hutchins A, Fryda L. The Impact of Virgin Coconut Oil and High-Oleic Safflower Oil on Body Composition, Lipids, and Inflammatory Markers in Postmenopausal Women. J Med Food 2017 Apr;20(4):345-351.

[30] Swarnamali H, Ranasinghe P, Jayawardena R. The effect of coconut oil and palm oil on anthropometric parameters: a clinical trial. BMC Nutrition 2024;10(1):9.

[31] Coleman H, Quinn P, Clegg ME. Medium-chain triglycerides and conjugated linoleic acids in beverage form increase satiety and reduce food intake in humans. Nutr Res 2016 Jun;36(6):526-533.

[32] Nogoy KMC, Kim HJ, Lee Y, Zhang Y, Yu J, Lee DH, et al. High dietary oleic acid in olive oil-supplemented diet enhanced omega-3 fatty acid in blood plasma of rats. Food Sci Nutr 2020 May 19;8(7):3617-3625.

[33] Hewlings S. Coconuts and Health: Different Chain Lengths of Saturated Fats Require Different Consideration. J Cardiovasc Dev Dis 2020 Dec 17;7(4):59. doi: 10.3390/jcdd7040059.

[34] Control Group, Turnbull FM, Abraira C, Anderson RJ, Byington RP, Chalmers JP, et al. Intensive glucose control and macrovascular outcomes in type 2 diabetes. Diabetologia 2009 Nov;52(11):2288-2298.

[35] Kelly TN, Bazzano LA, Fonseca VA, Thethi TK, Reynolds K, He J. Systematic review: glucose control and cardiovascular disease in type 2 diabetes. Ann Intern Med 2009 Sep 15;151(6):394-403.

[36] Amezcua-Castillo E, González-Pacheco H, Sáenz-San Martín A, Méndez-Ocampo P, Gutierrez-Moctezuma I, Massó F, et al. C-Reactive Protein: The Quintessential Marker of Systemic Inflammation in Coronary Artery Disease-Advancing toward Precision Medicine. Biomedicines 2023 Sep 2;11(9):2444. doi: 10.3390/biomedicines11092444.

[37] Angeles-Agdeppa I, Nacis JS, Capanzana MV, Dayrit FM, Tanda KV. Virgin coconut oil is effective in lowering C-reactive protein levels among suspect and probable cases of COVID-19. J Funct Foods 2021 Aug;83:104557.

[38] Karrunanithi S, Ravichandran KA, Hima L, Pratap U, Vasantharekha R, Thyagarajan S. Virgin coconut oil enhances neuroprotective and anti-inflammatory factors in the thymus and mesenteric lymph nodes of rats. Clinical and Experimental Neuroimmunology 2019 /09/09;11.

[39] Famurewa AC, Folawiyo AM, Enohnyaket EB, Azubuike-Osu SO, Abi I, Obaje SG, et al. Beneficial role of virgin coconut oil supplementation against acute methotrexate chemotherapy-induced oxidative toxicity and inflammation in rats. Integr Med Res 2018 Sep;7(3):257-263.

[40] Fuchs FD, Whelton PK. High Blood Pressure and Cardiovascular Disease. Hypertension 2020 Feb;75(2):285-292.

[41] Marina AM, Man YBC, Nazimah SAH, Amin I. Antioxidant capacity and phenolic acids of virgin coconut oil. Int J Food Sci Nutr 2009;60 Suppl 2:114-123.

[42] Nevin KG, Rajamohan T. Virgin coconut oil supplemented diet increases the antioxidant status in rats. Food Chem 2006;99(2):260-266.

[43] Mensink RP, Zock PL, Kester ADM, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. Am J Clin Nutr 2003 May;77(5):1146-1155.

[44] Toth PP, Barter PJ, Rosenson RS, Boden WE, Chapman MJ, Cuchel M, et al. High-density lipoproteins: a consensus statement from the National Lipid Association. J Clin Lipidol 2013;7(5):484-525.

[45] Gordon DJ, Probstfield JL, Garrison RJ, Neaton JD, Castelli WP, Knoke JD, et al. High-density lipoprotein cholesterol and cardiovascular disease. Four prospective American studies. Circulation 1989 Jan;79(1):8-15.

[46] Frick MH, Elo O, Haapa K, Heinonen OP, Heinsalmi P, Helo P, et al. Helsinki Heart Study: primary-prevention trial with gemfibrozil in middle-aged men with dyslipidemia. Safety of treatment, changes in risk factors, and incidence of coronary heart disease. N Engl J Med 1987 Nov 12;317(20):1237-1245.

[47] Melin EO, Thulesius HO, Hillman M, Svensson R, Landin-Olsson M, Thunander M. Lower HDL-cholesterol, a known marker of cardiovascular risk, was associated with depression in type 1 diabetes: a cross sectional study. Lipids Health Dis 2019 Mar 18;18(1):65-4.

[48] Duarte AC, Spiazzi BF, Zingano CP, Merello EN, Wayerbacher LF, Teixeira PP, et al. The effects of coconut oil on the cardiometabolic profile: a systematic review and meta-analysis of randomized clinical trials. Lipids Health Dis 2022 Aug 31;21(1):83-z.

[49] Eyres L, Eyres MF, Chisholm A, Brown RC. Coconut oil consumption and cardiovascular risk factors in humans. Nutr Rev 2016 Apr;74(4):267-280.

[50] DiNicolantonio JJ, O'Keefe JH. Omega-6 vegetable oils as a driver of coronary heart disease: the oxidized linoleic acid hypothesis. Open Heart 2018 Sep 26;5(2):e000898-000898. eCollection 2018.

[51] Ekanayaka RAI, de Silva PGSM, Ekanayaka MKI, Jayathilake WMM, Pathirana RPMMR, Amaratunga YN, et al. Effect of different forms of coconut on the lipid profile in normal free-living healthy subjects: A randomized controlled trial (Phase II). Glob Epidemiol 2024 Feb 2;7:100138.

[52] Famurewa AC, Ejezie AJ, Ugwu-Ejezie CS, Ikekpeazu EJ, Ejezie FE. Antioxidant and anti-inflammatory mechanisms of polyphenols isolated from virgin coconut oil attenuate cadmium-

induced oxidative stress-mediated nephrotoxicity and inflammation in rats. Journal of Applied Biomedicine 2018;16(4):281-288.

[53]. Beulen Y, Martínez-González MA, van de Rest O, Salas-Salvadó J, Sorlí JV, Gómez-Gracia E, et al. Quality of Dietary Fat Intake and Body Weight and Obesity in a Mediterranean Population: Secondary Analyses within the PREDIMED Trial. Nutrients 2018 Dec 19;10(12):2011. doi: 10.3390/nu10122011.

[54] Ravnskov U, Diamond DM, Hama R, Hamazaki T, Hammarskjöld B, Hynes N, et al. Lack of an association or an inverse association between low-density-lipoprotein cholesterol and mortality in the elderly: a systematic review. BMJ Open 2016 Jun 12;6(6):e010401-010401.

[55] Loganathan R, Nagapan G, Teng K, Voon PT, Yap SY, Ng YT, et al. Diets enriched with palm olein, cocoa butter, and extra virgin olive oil exhibited similar lipid response: a randomized controlled study in young healthy adults. Nutr Res 2022 Sep;105:113-125.