



INTAKE OF PALM OLEIN AND LIPID STATUS IN HEALTHY ADULTS

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Palm Oil Health Awareness Evening Seminar & Dinner 20 August 2022



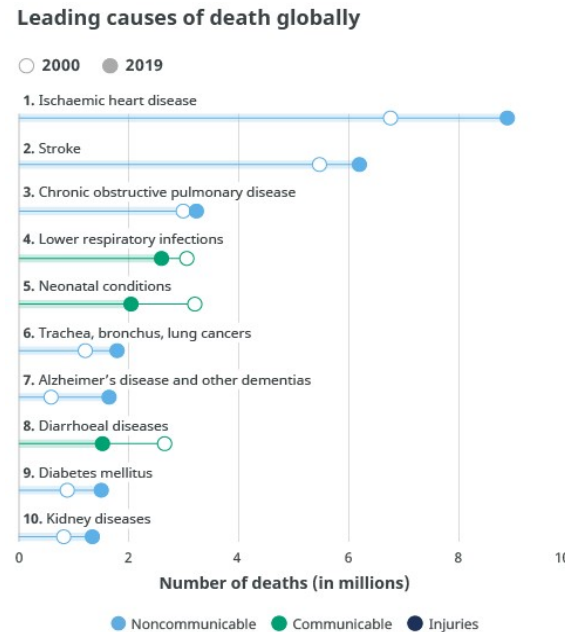
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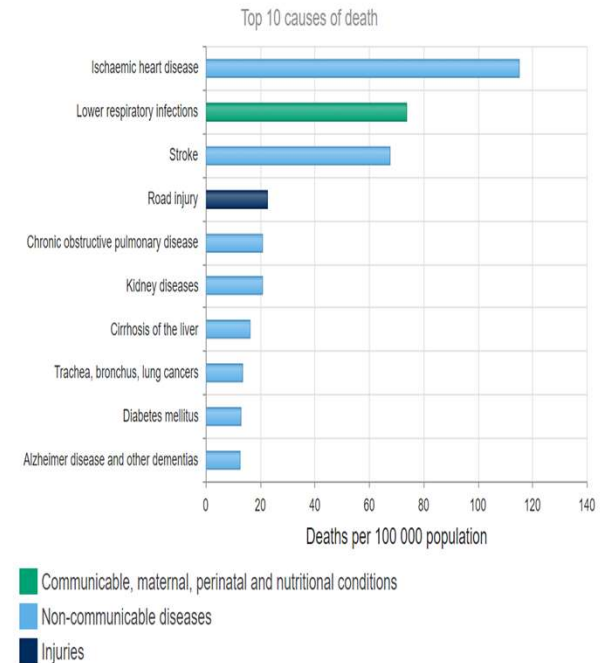
INTRODUCTION

- According to the World Health Organization, cardiovascular disease (CVD) is the number one cause of death globally.
- One major contributor to CVD is related to diet high in saturated fat that increases serum lipid level.
- Increased levels of LDL-C have been shown to increase the risk of CVD.
- Saturated fats intake has also been extensively discussed as one of the main reason for the clinical problem of dyslipidaemia, that associated with CVD.

Top 10 global causes of deaths
(2000 vs 2019)



Top 10 causes of death in Malaysia for
both sexes aged all ages
(2019)

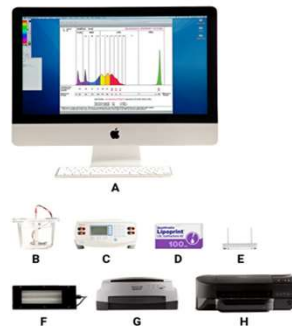
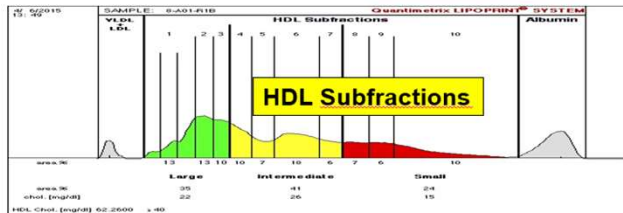
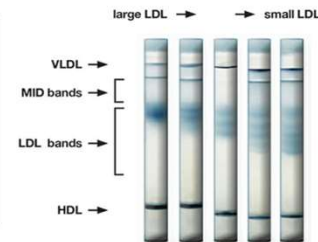
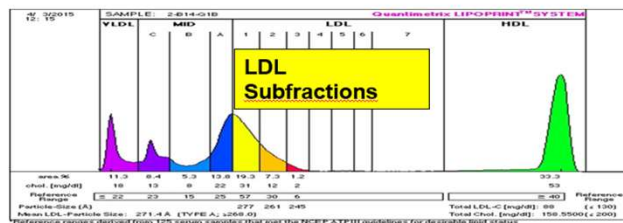


Recent reviews on saturated fats

Outcome	Review	
Consumption of saturated fats in the diet did not lead to significant reduction in CVD.	Chowdhury et al, 2014 Kuipers et al, 2011 Skeaff et al, 2009 Siri-Tarino et al, 2010 Astrup et al, 2011	Mozaffarian et al, 2011 Laura et al, 2015 De Souza et al, 2015 Dehghan et al, 2017 Gershuni et al, 2018 Federica et al, 2021
Saturated fats might even be cardioprotective/ reduce risk of stroke.	De Oliveira et al, 2012 Astrup et al, 2020 Kang et al, 2020	
Replacing SFA with PUFA lower the risk of CVD, but too much of PUFA might be detrimental to those antioxidant-compromised individuals.	Sacks et al, 2017 Ramsden et al, 2013	
SFAs ↑ LDL cholesterol => ↑ large LDL particles, small, dense LDL particles not affected. So, less detrimental to CVD risk.	Diamond et al, 2020	
Lack of evidence to support the continuation of the U.S. Dietary Guidelines for Americans to limit the consumption of SFA ($\leq 10\%$ intake) or to replace SFA with PUFA.	Harcombe et al, 2015 Harcombe et al, 2016 Harcombe et al, 2017 DuBroff & Longetil, 2019 Astrup et al, 2021	

- SFAs $\uparrow$ LDL cholesterol $\Rightarrow$ $\uparrow$ large LDL particles, small-dense LDL particles $\Rightarrow$ not affected. So, less detrimental to CVD risk (Diamond et al. 2020)
- Palm olein was found does not affects the small, dense LDL cholesterol compared to MUFA rich fats (Cheng et al, 2018, Stonehouse et al, 2020, Loganathan et al, 2022)

Lipid profile



Traditional Risk Factors Don't Tell the Whole Story

- The fact is that approximately 50% of CAD occurs among individuals with normal lipid levels
- Only 30% of all heart attacks can be explained on the basis of total cholesterol measurements alone

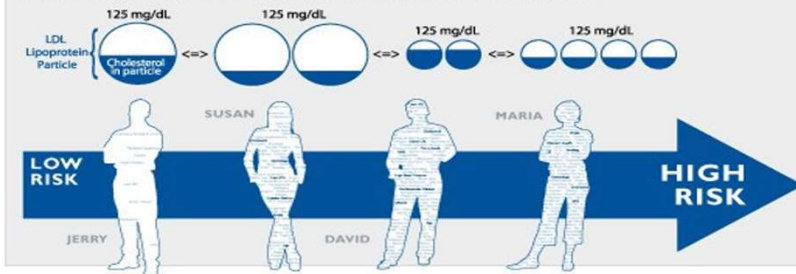
The Size/Density and Number of Particles Determine Your Risk

LDL CHOLESTEROL MEASUREMENTS DO NOT DETERMINE THE NUMBER OF LDL PARTICLES
 LDL particles can be large or small, and the amount of cholesterol contained within these particles varies widely. Smaller particles have a greater risk of causing cardiovascular disease. An increased number of particles also has a higher risk. Bigger is better!

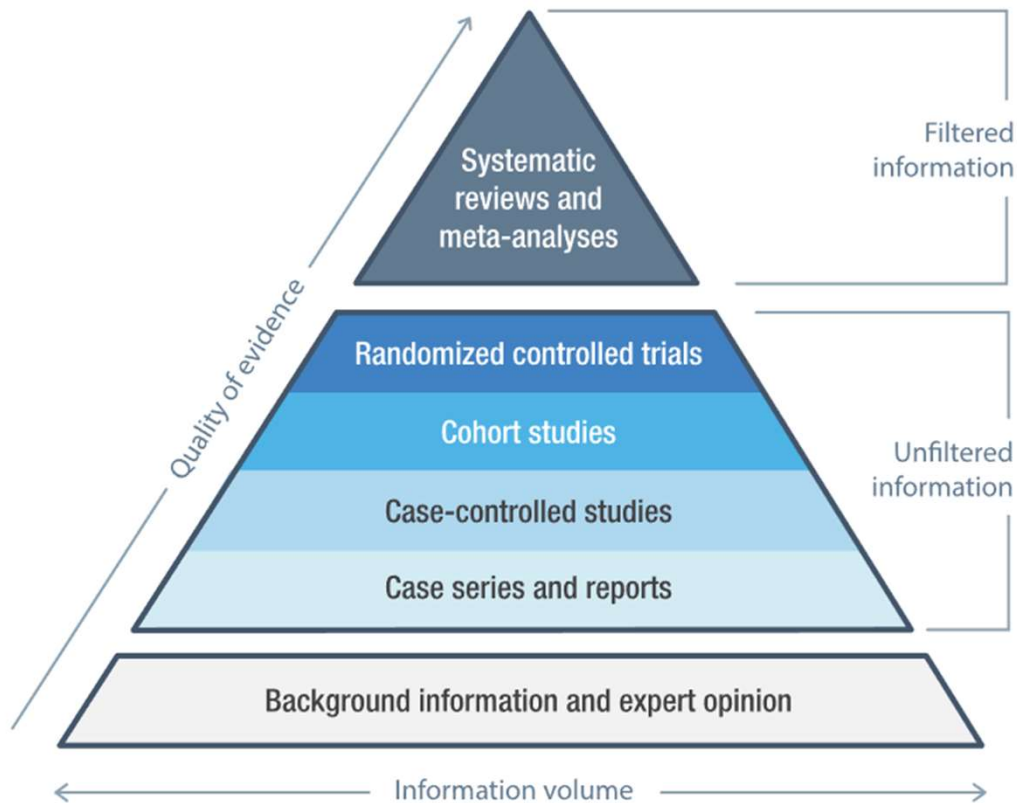
LIPOPROTEIN PARTICLES VS. CHOLESTEROL

Each patient shown has the same LDL cholesterol of 125 mg/dL.

Maria has the higher risk because her LDL particles are the smallest and she has a lot of them.



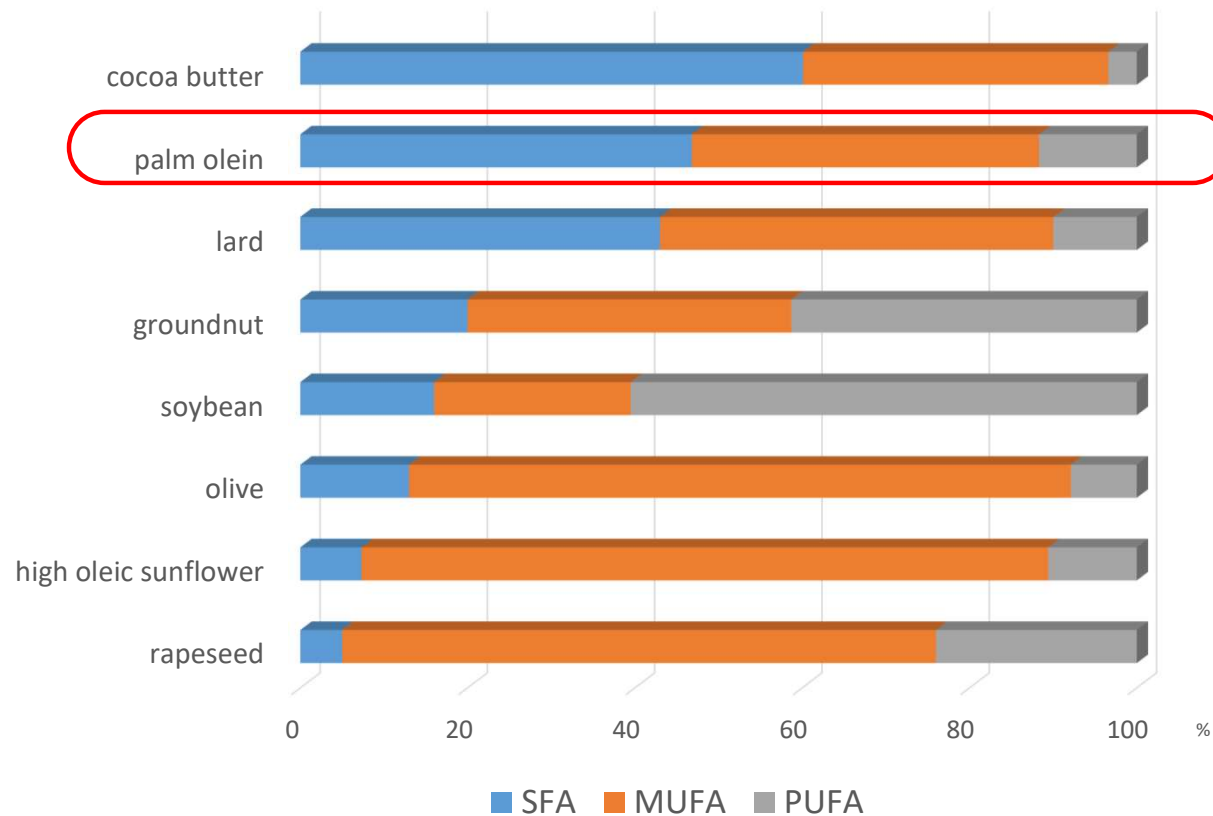
Levels of Evidence



The Concept of a Systematic Review



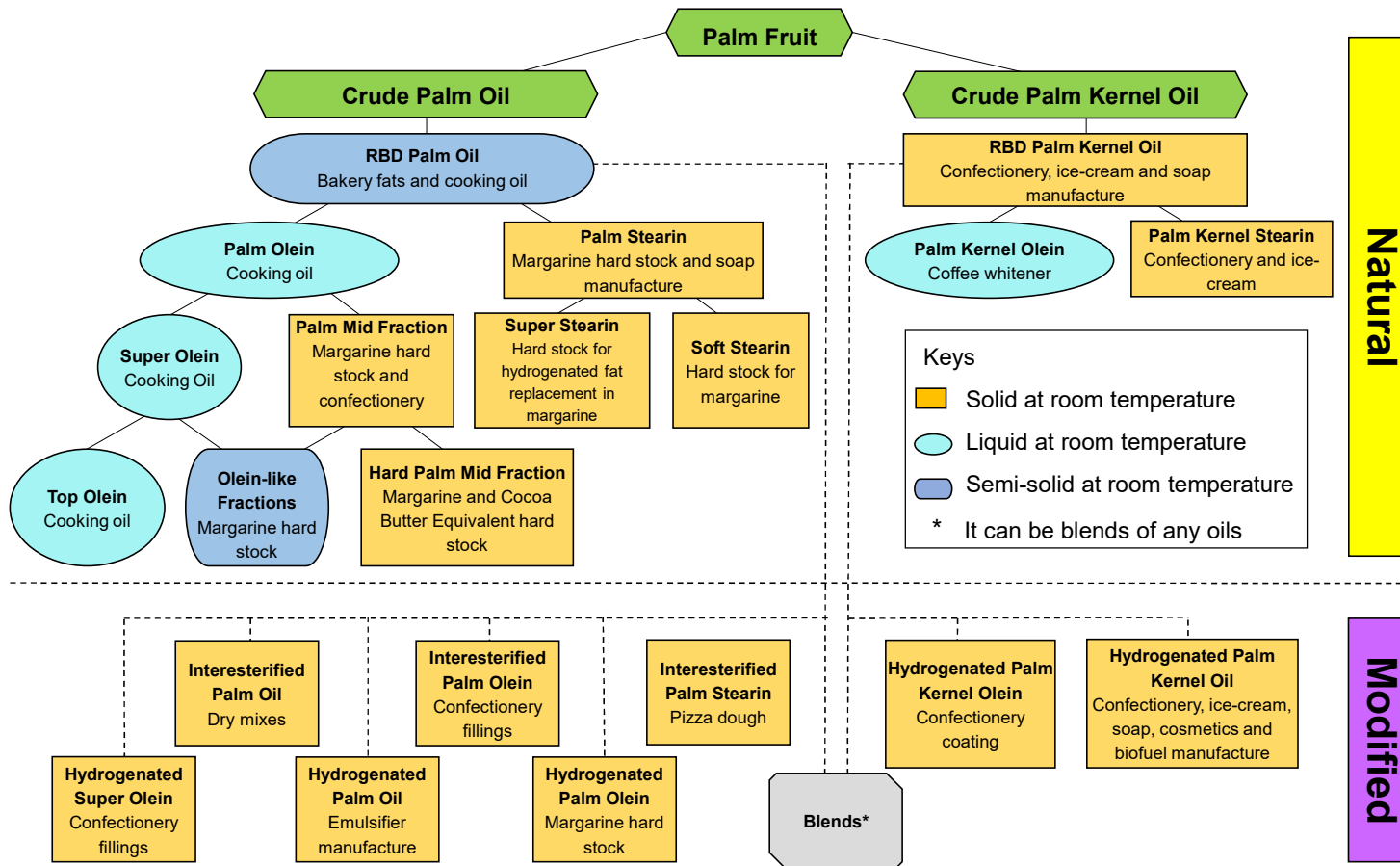
TOTAL FATTY ACID COMPOSITION OF COMMON EDIBLE OILS & FATS



Palm oil: almost equal amounts of saturated fatty acids and unsaturated fatty acids.



Palm Oil is Versatile



- Palm oil (semi-solid at room temperature) - palm olein (liquid fraction) and palm stearin (solid fraction).
- Palm olein (clear and colorless at room temperature) contains higher levels of total oleic acid (39-45%) and linoleic acid (10-13%).
- Palm olein - fractionated into palm super olein (IV > 60) and palm top olein (IV 70-72).
- Palm olein with high IVs (IV 70-72 having cloud point of below 0°C) are produced for temperate countries.
- These oleins (palm olein, palm super olein, palm top olein) referred as liquid fraction of palm oil or just as "palm olein" in general are suitable for cooking.

- Palm oil can be used as **an alternative to partial hydrogenated fat** – many concerns - not nutritionally ideal? has adverse effects on lipid profile? high saturated fatty acids content?
- Palm oil use in humans has been reviewed, but **the effect of palm olein as a whole has not been discussed.**
- **Palm olein** is commonly used as a **household cooking oil** in South East Asia and sub-Saharan Africa.

Aim of this study :

- **Compare the effect of palm olein with other cooking oils**, without the interference from other palm oil fractions, modified fats and blended oils in healthy adults that represent the majority of general populations.
- Investigate **the effect of palm olein on blood lipid profile** in healthy adults.



Exclusion criteria

We excluded interventions using

- i. **crude palm oil** or **red palm olein**,
- ii. **modified oil**, for examples chemically interesterified-, enzymatically interesterified- or hydrogenated- palm oils,
- iii. **palm oil blended** with any other oils,
- iv. **palm oil fraction** such as palm kernel oil, palm stearin, and palm mid fraction that were incorporated as test fats.

- The search was conducted using the **standard Cochrane procedures**. We searched published articles from 1975 (when palm oil refining and fractionation facilities were established and widely expanded) to January 2018, through MEDLINE (<http://www.ncbi.nlm.nih.gov/pubmed>) and CENTRAL (Central Register of Controlled Trials; <http://www.cochranelibrary.com/>) for randomized controlled feeding trials of palm olein.
- From the selected articles, we also searched the reference lists to identify potential articles not generated in the databases.



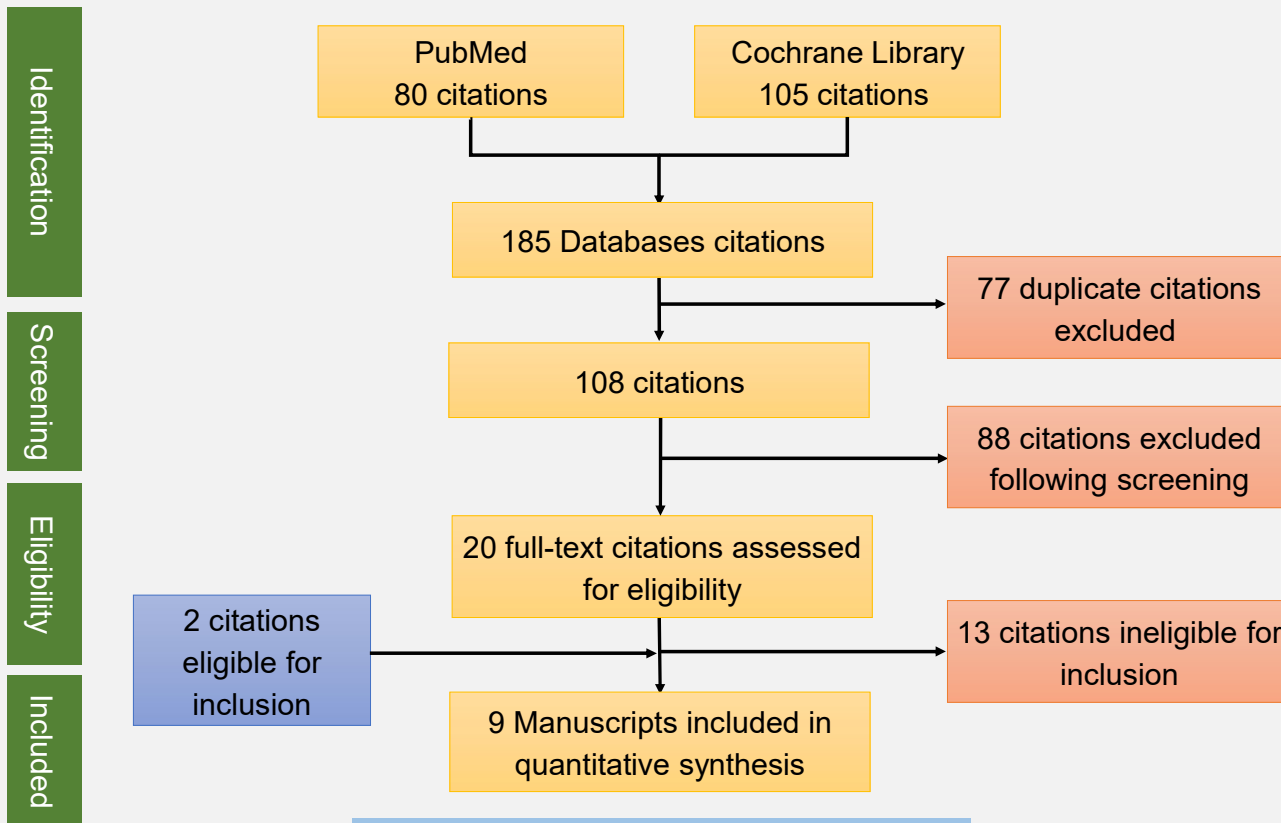
Keywords and MeSH terms for search strategy



Combinations of the following keywords were used: palm oil, palm olein, cholesterol, triglyceride, triacylglycerol, lipoprotein, clinical trial, and humans.

((("palm oil"[Supplementary Concept] OR "palm oil"[All Fields]) OR (palm[All Fields] AND olein[All Fields])) AND (("cholesterol"[MeSH Terms] OR "cholesterol"[All Fields]) OR ("triglycerides"[MeSH Terms] OR "triglycerides"[All Fields] OR "triglyceride"[All Fields]) OR ("triglycerides"[MeSH Terms] OR "triglycerides"[All Fields] OR "triacylglycerol"[All Fields]) OR ("lipoproteins"[MeSH Terms] OR "lipoproteins"[All Fields] OR "lipoprotein"[All Fields])) AND (Clinical Trial [ptyp] AND "humans"[MeSH Terms])) for the MEDLINE search; (palm oil OR palm olein) AND (cholesterol OR triglyceride OR triacylglycerol OR lipoprotein) for the Cochrane Library search.

Selection of Studies



PRISMA diagram

- All abstracts and full-text articles were evaluated based on the inclusion and exclusion criteria by four investigators independently.
- Technical consultations with three other investigators were sought and any disagreement was resolved by consensus.
- In the process, we removed any duplicate papers.



Data collection



Information extraction on

- Authors
- Publication year (1975 – 2018)
- Characteristics of the subjects (gender, age, and health condition)
- Drop-out rates
- Study designs (crossover or parallel, single or double blind)
- Duration of feeding
- Use of run-in and/or wash-out periods
- Oils used as interventions and comparisons (type, fatty acid composition, energy percentage)
- Lipid profile changes, along with the corresponding SE, SD and 95% CI value.

Results were tabulated in two different entries when genders were reported separately.

Quality Assessment

- Risk of bias was assessed using the Cochrane Risk of Bias Tool.
- For each criterion, risk of bias was classified into low, unclear, or high for each study.

Study 8	Study 7	Study 6	Study 5	Study 4	Study 3	Study 2	Study 1	
+	+	+	+	+	+	+	?	Random sequence generation (selection bias)
+	+	+	?	+	+	+	?	Allocation concealment (selection bias)
-	-	-	-	-	-	-	-	Blinding of participants and personnel (performance bias)
?	+	?	?	+	-	+	-	Blinding of outcome assessment (detection bias)
+	?	+	-	+	-	+	?	Incomplete outcome data (attrition bias)
+	+	+	+	+	+	+	+	Selective reporting (reporting bias)
?	+	+	+	+	?	?	+	Other bias

Statistical Analysis

- Classification of the comparison test diets into i) diet rich in palm olein, and ii) diet rich in other oil.
- Subgroup analyzes comparing diet rich in palm olein versus SFA-, MUFA- and PUFA-rich oils were also conducted.
- Standardization of all the reported mean values of TC, LDL-C, HDL-C and TG into mmol/L.
- Review Manager 5.3 was used to perform the statistical analyzes.
- A fixed effect model and assessed the heterogeneity between studies using the chi-square test for homogeneity, defining significant heterogeneity if the p value is less than 0.1 was used.
- The heterogeneity using the I^2 statistics, which represents the percentage of total variation across studies that is attributable to heterogeneity rather than to chance were quantified.
- I^2 of >75% as high heterogeneity, 50-75% as moderate heterogeneity, and <50% as low heterogeneity.
- If the I^2 is high, a random effect model will be performed and reported.

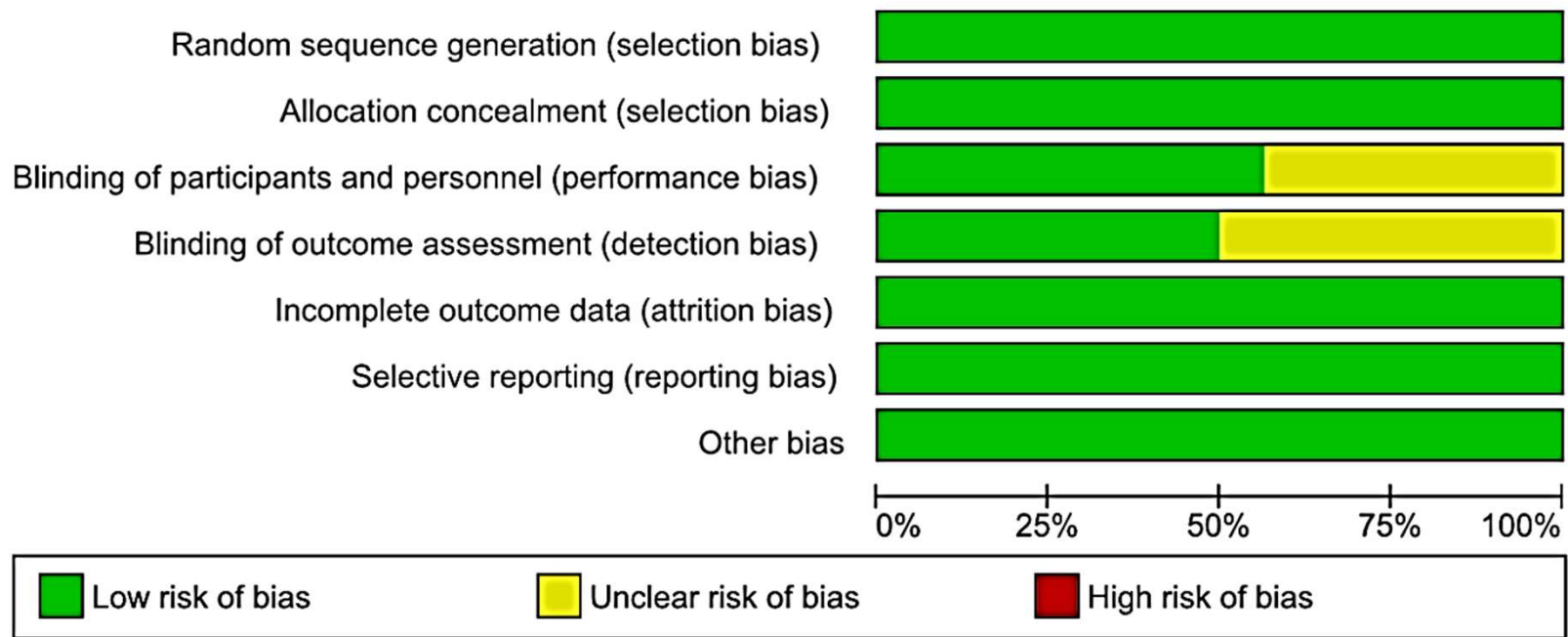


	Excluding parallel studies	Excluding crossover studies	All studies
LDL-Cholesterol			
P-value	0.87	0.36	0.56
I ² (%)	86	80	85
Mean difference	-0.02	-0.17	-0.06
HDL-Cholesterol			
P-value	0.41	0.0002	0.2
I ² (%)	39	46	59
Mean difference	-0.01	0.10	0.02
TC			
P-value	0.46	0.55	0.34
I ² (%)	82	70	79
Mean difference	-0.10	-0.09	-0.10
TG			
P-value	0.53	0.35	0.85
I ² (%)	0	3	0
Mean difference	0.02	-0.07	0.01
TC/HDL cholesterol			
P-value	0.22	0.0003	0.32
I ² (%)	0	22	64
Mean difference	0.12	-0.60	-0.15

Sensitivity analyses comparing the differences between unit of analysis that involved studies using crossover and parallel designs approaches.

Pooling of the 2 different designs in dietary interventions was found appropriate.

Risk of Bias



Risk of Bias Summary

All studies were assessed to have low risk of selection bias, attrition bias, reporting bias and other bias.

2 studies with unclear risk of performance bias and 4 studies with unclear risk of detection bias.

Choudhury et al. (27) (OO)	+	+	+	+	+	+	+
Filippou et al. (23) (HOS)	+	+	+	+	+	+	+
Lucci et al. (29) (OO)	+	+	+	?	+	+	+
Ng et al. (21) (CO)	+	+	+	+	+	+	+
Ng et al. (22) (CO-F)	+	+	?	?	+	+	+
Ng et al. (22) (CO-M)	+	+	?	?	+	+	+
Ng et al. (22) (OO-F)	+	+	?	?	+	+	+
Ng et al. (22) (OO-M)	+	+	?	?	+	+	+
Sun et al. (26) (OO)	+	+	+	+	+	+	+
Vega-Lopez et al. (28) (CAN)	+	+	+	?	+	+	+
Vega-Lopez et al. (28) (SBO)	+	+	+	?	+	+	+
Voon et al. (24) (CO)	+	+	+	+	+	+	+
Voon et al. (24) (OO)	+	+	+	+	+	+	+
Zhang et al. (25) (L)	+	+	?	+	+	+	+
Zhang et al. (25) (PE)	+	+	?	+	+	+	+
Zhang et al. (25) (SBO)	+	+	?	+	+	+	+

Random sequence generation (selection bias)

Allocation concealment (selection bias)

Blinding of participants and personnel (performance bias)

Blinding of outcome assessment (detection bias)

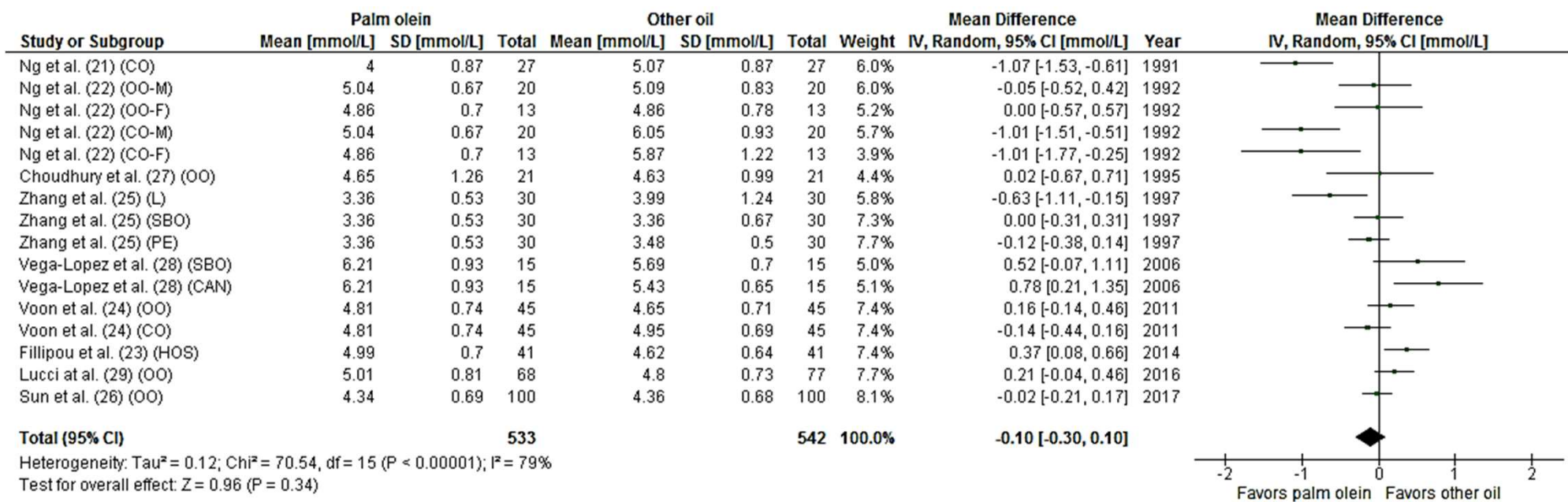
Incomplete outcome data (attrition bias)

Selective reporting (reporting bias)

Other bias

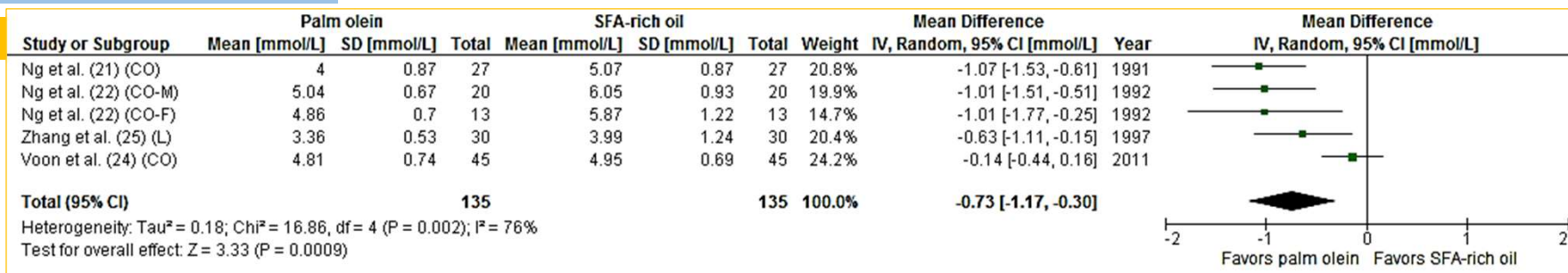
Total Cholesterol

Palm olein vs other oils

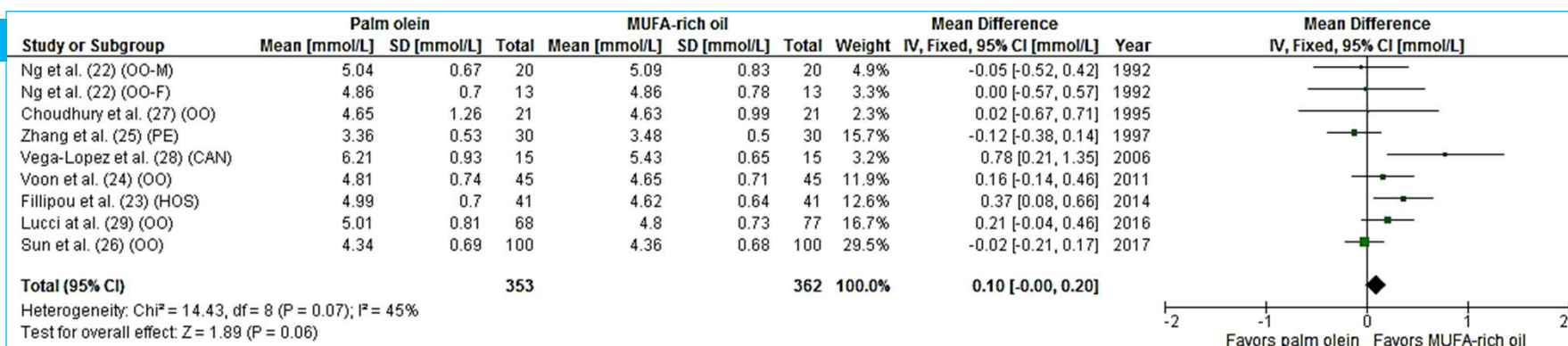


Total Cholesterol

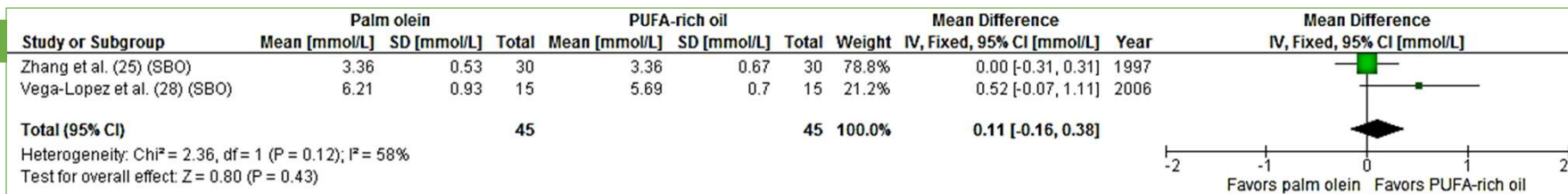
vs SFA-rich oil



vs MUFA-rich oil



vs PUFA-rich oil



LDL-Cholesterol

Palm olein vs other oils

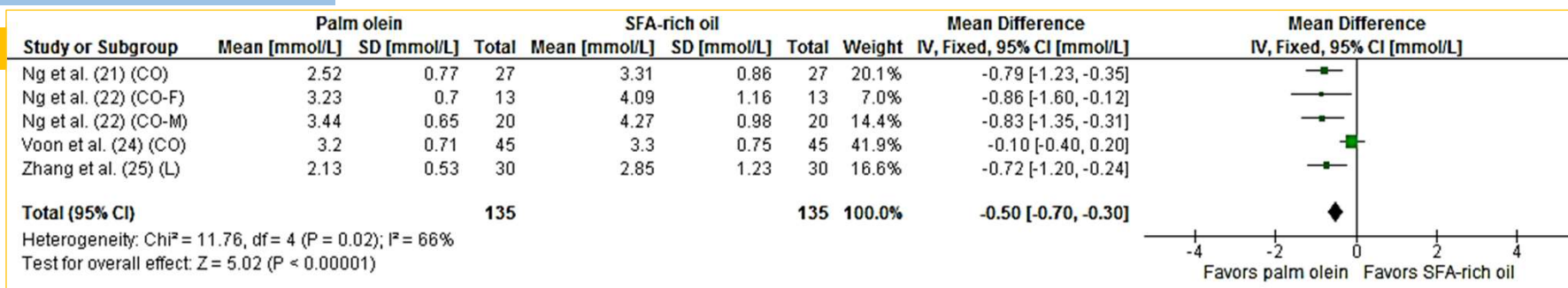
Study or Subgroup	Palm olein			Other oil			Weight	Mean Difference	Year	Mean Difference
	Mean [mmol/L]	SD [mmol/L]	Total	Mean [mmol/L]	SD [mmol/L]	Total		IV, Random, 95% CI [mmol/L]		IV, Random, 95% CI [mmol/L]
Ng et al. (21) (CO)	2.52	0.77	27	3.31	0.86	27	6.2%	-0.79 [-1.23, -0.35]	1991	
Ng et al. (22) (OO-F)	3.23	0.7	13	3.28	0.78	13	5.3%	-0.05 [-0.62, 0.52]	1992	
Ng et al. (22) (CO-F)	3.23	0.7	13	4.09	1.16	13	4.4%	-0.86 [-1.60, -0.12]	1992	
Ng et al. (22) (OO-M)	3.44	0.65	20	3.47	0.8	20	6.1%	-0.03 [-0.48, 0.42]	1992	
Ng et al. (22) (CO-M)	3.44	0.65	20	4.27	0.98	20	5.7%	-0.83 [-1.35, -0.31]	1992	
Choudhury et al. (27) (OO)	3.3	1.13	21	3.41	0.96	21	4.9%	-0.11 [-0.74, 0.52]	1995	
Zhang et al. (25) (L)	2.13	0.53	30	2.85	1.23	30	5.9%	-0.72 [-1.20, -0.24]	1997	
Zhang et al. (25) (SBO)	2.13	0.53	30	2.22	0.62	30	7.1%	-0.09 [-0.38, 0.20]	1997	
Zhang et al. (25) (PE)	2.13	0.53	30	2.41	0.45	30	7.3%	-0.28 [-0.53, -0.03]	1997	
Vega-Lopez et al. (28) (SBO)	4.27	0.91	15	3.75	0.62	15	5.4%	0.52 [-0.04, 1.08]	2006	
Vega-Lopez et al. (28) (CAN)	4.27	0.91	15	3.62	0.6	15	5.5%	0.65 [0.10, 1.20]	2006	
Voon et al. (24) (OO)	3.2	0.71	45	3.06	0.64	45	7.2%	0.14 [-0.14, 0.42]	2011	
Voon et al. (24) (CO)	3.2	0.71	45	3.3	0.75	45	7.0%	-0.10 [-0.40, 0.20]	2011	
Fillipou et al. (23) (HOS)	3.62	0.65	41	2.72	0.61	41	7.2%	0.90 [0.63, 1.17]	2014	
Lucci et al. (29) (OO)	2.77	0.94	68	2.47	0.87	77	7.1%	0.30 [0.00, 0.60]	2016	
Sun et al. (26) (OO)	2.48	0.69	100	2.51	0.5	100	7.7%	-0.03 [-0.20, 0.14]	2017	
Total (95% CI)			533			542	100.0%	-0.06 [-0.29, 0.16]		

Heterogeneity: Tau² = 0.17; Chi² = 97.82, df = 15 (P < 0.00001); I² = 85%
Test for overall effect: Z = 0.54 (P = 0.59)

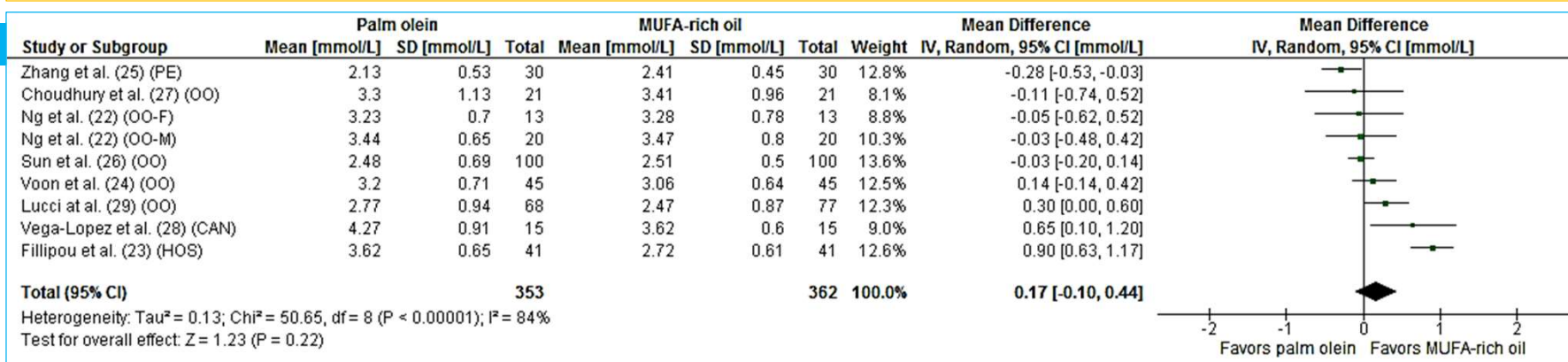
-2 -1 0 1 2
Favors palm olein Favors other oil

LDL-Cholesterol

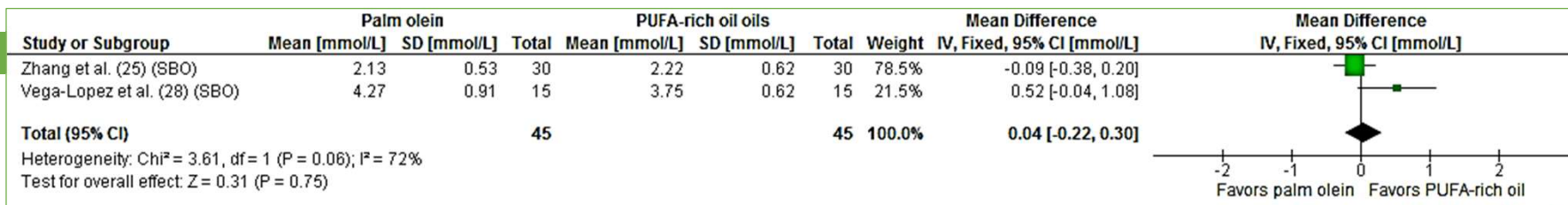
vs SAFA-rich oil



vs MUFA-rich oil

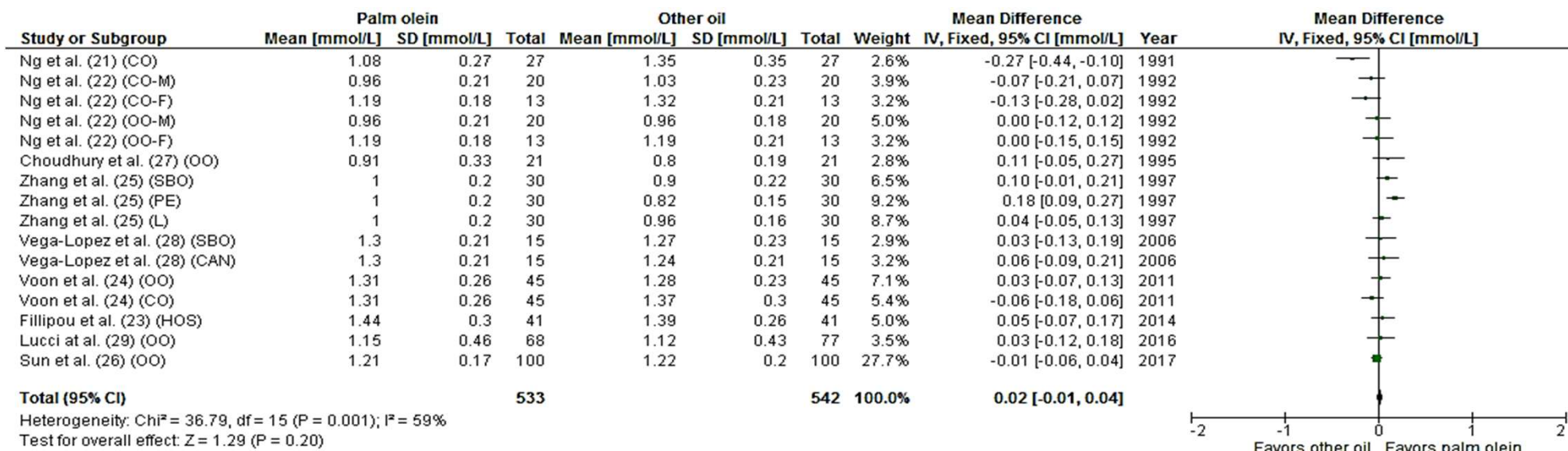


vs PUFA-rich oil



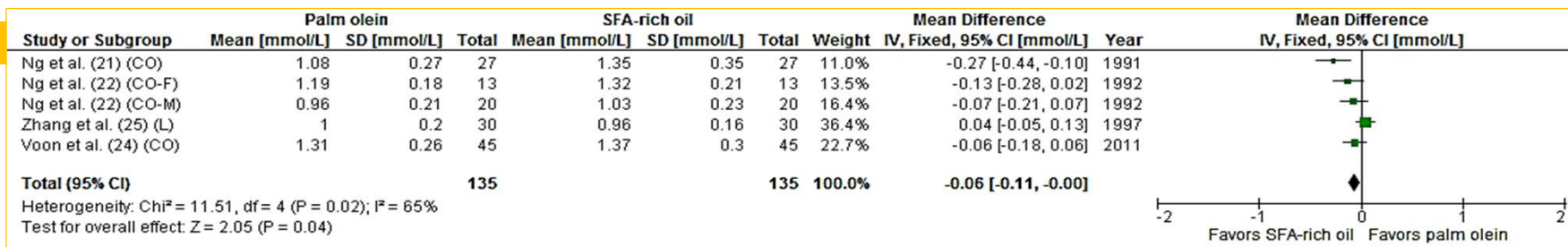
HDL-Cholesterol

Palm olein vs other oils

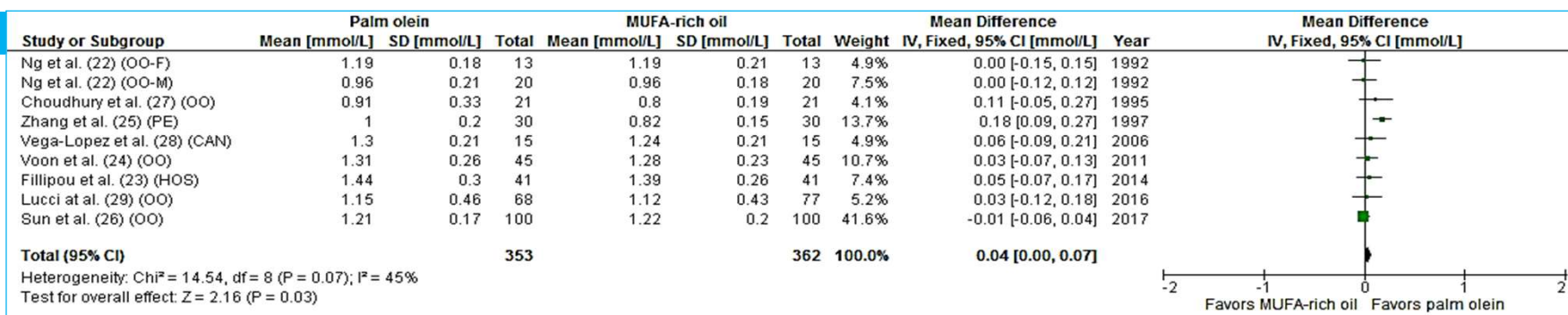


HDL-Cholesterol

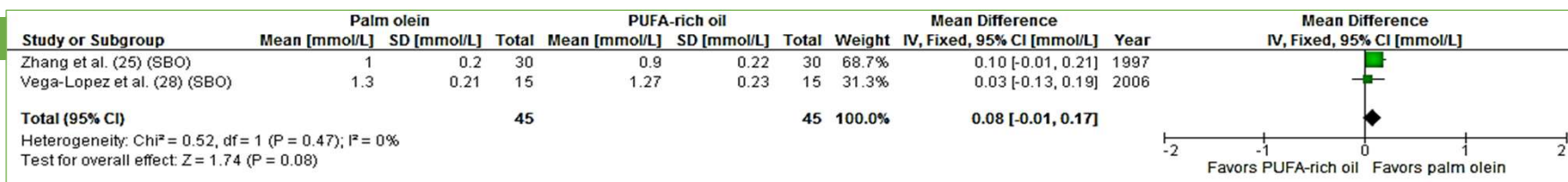
vs SFA-rich oil



vs MUFA-rich oil

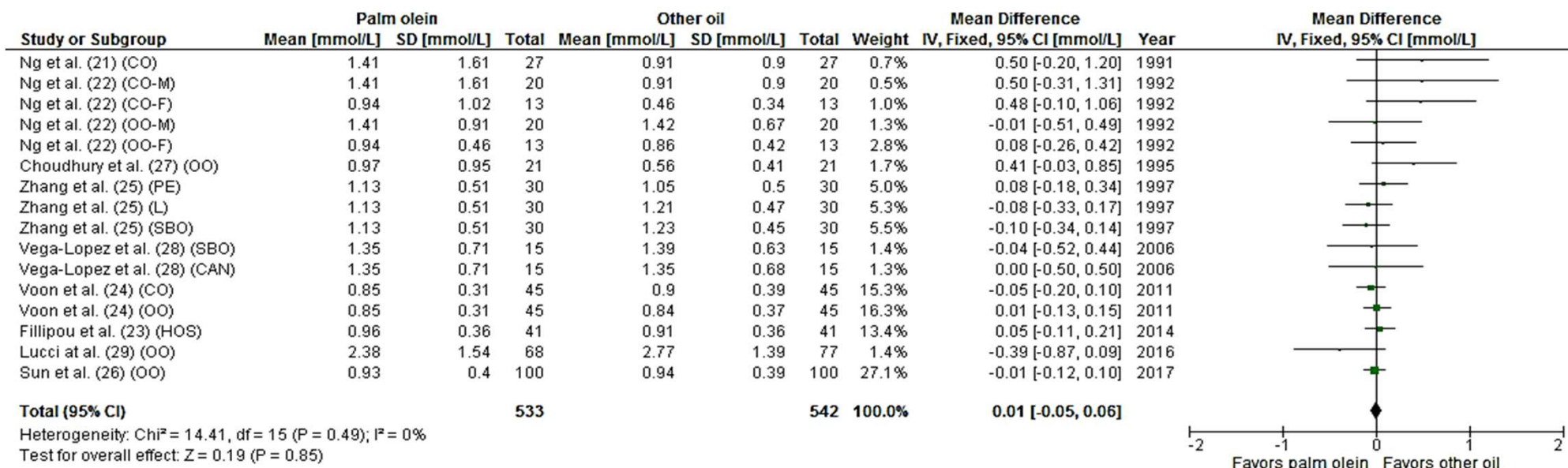


vs PUFA-rich oil



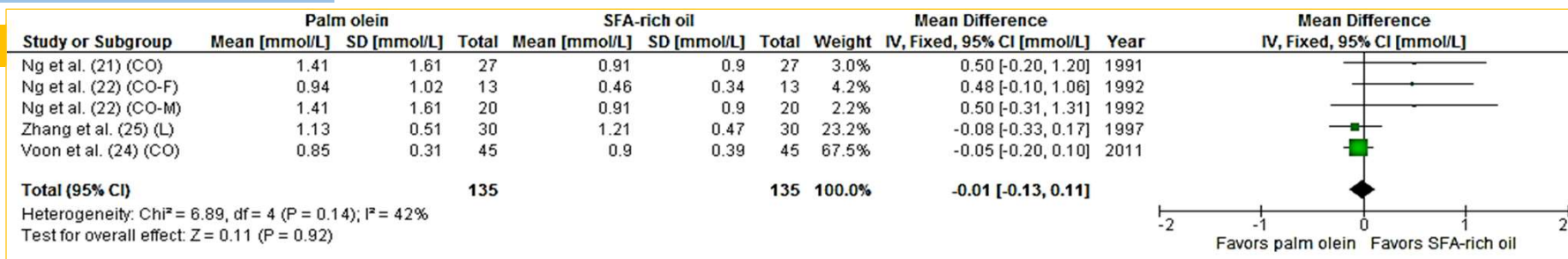
Triglycerides

Palm olein vs other oils

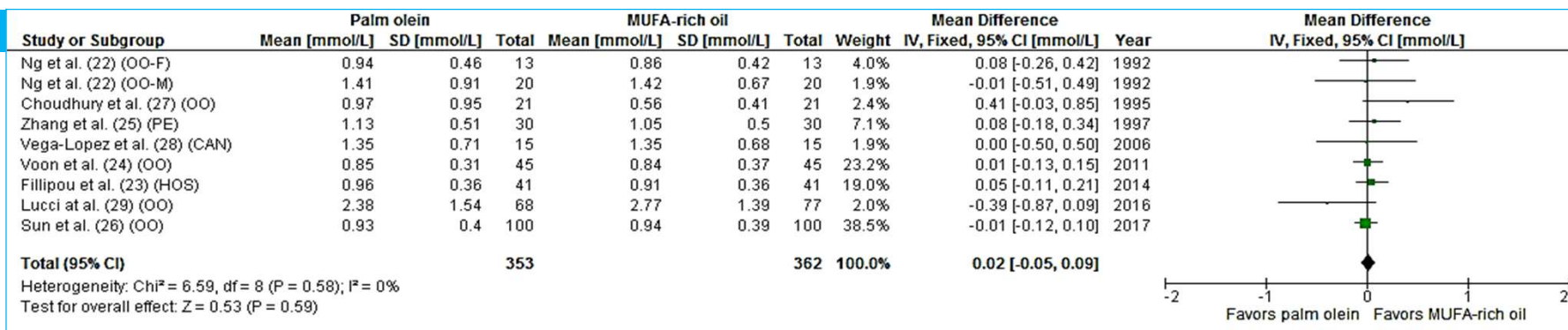


Triglycerides

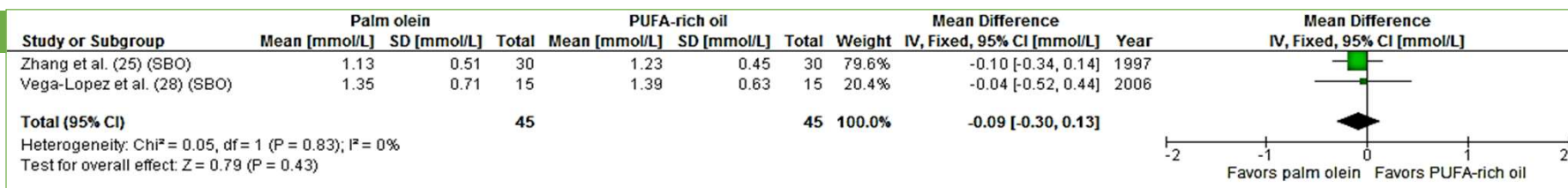
vs SAFA-rich oil



vs MUFA-rich oil



vs PUFA-rich oil

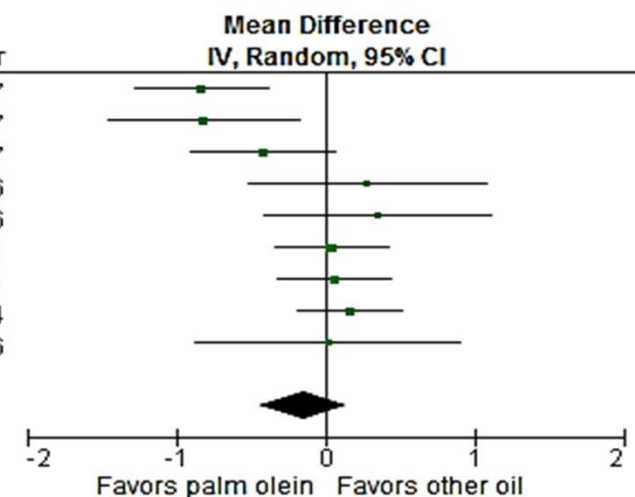


TC/HDL ratio

Palm olein vs other oils

Study or Subgroup	Palm olein			Other oil			Weight	Mean Difference IV, Random, 95% CI	Year
	Mean	SD	Total	Mean	SD	Total			
Zhang et al. (25) (PE)	3.49	0.92	30	4.32	0.86	30	12.8%	-0.83 [-1.28, -0.38]	1997
Zhang et al. (25) (L)	3.49	0.92	30	4.31	1.54	30	9.7%	-0.82 [-1.46, -0.18]	1997
Zhang et al. (25) (SBO)	3.49	0.92	30	3.91	1	30	12.2%	-0.42 [-0.91, 0.07]	1997
Vega-Lopez et al. (28) (SBO)	4.89	1.06	15	4.61	1.17	15	7.6%	0.28 [-0.52, 1.08]	2006
Vega-Lopez et al. (28) (CAN)	4.89	1.06	15	4.54	1.06	15	8.1%	0.35 [-0.41, 1.11]	2006
Voon et al. (24) (CO)	3.69	0.9	45	3.65	0.95	45	14.1%	0.04 [-0.34, 0.42]	2011
Voon et al. (24) (OO)	3.69	0.9	45	3.63	0.93	45	14.1%	0.06 [-0.32, 0.44]	2011
Fillipou et al. (23) (HOS)	3.52	0.82	41	3.35	0.8	41	14.6%	0.17 [-0.18, 0.52]	2014
Lucci at al. (29) (OO)	5.36	2.48	68	5.34	2.98	77	6.7%	0.02 [-0.87, 0.91]	2016
Total (95% CI)			319			328	100.0%	-0.15 [-0.43, 0.14]	

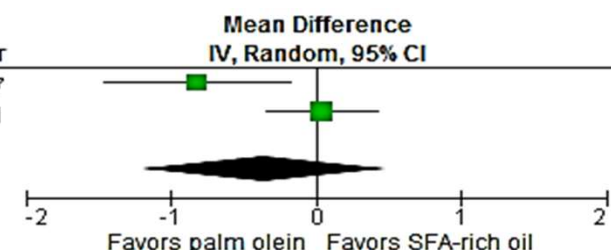
Heterogeneity: $\tau^2 = 0.11$; $\chi^2 = 22.27$, $df = 8$ ($P = 0.004$); $I^2 = 64\%$
 Test for overall effect: $Z = 1.00$ ($P = 0.32$)



TC/HDL ratio

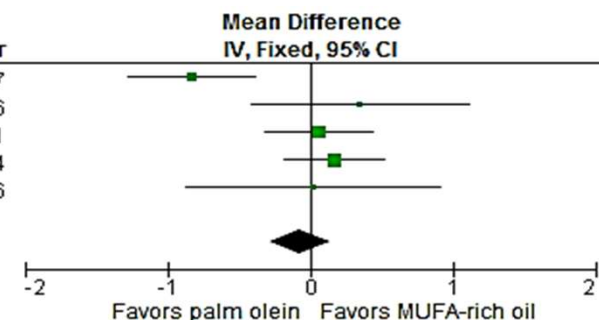
vs SAFA-rich oil

Study or Subgroup	Palm olein			SFA-rich oil			Weight	Mean Difference IV, Random, 95% CI	Year
	Mean	SD	Total	Mean	SD	Total			
Zhang et al. (25) (L)	3.49	0.92	30	4.31	1.54	30	45.3%	-0.82 [-1.46, -0.18]	1997
Voon et al. (24) (CO)	3.69	0.9	45	3.65	0.95	45	54.7%	0.04 [-0.34, 0.42]	2011
Total (95% CI)			75			75	100.0%	-0.35 [-1.19, 0.49]	
Heterogeneity: $\tau^2 = 0.30$; $\chi^2 = 5.09$, $df = 1$ ($P = 0.02$); $I^2 = 80\%$									
Test for overall effect: $Z = 0.82$ ($P = 0.41$)									



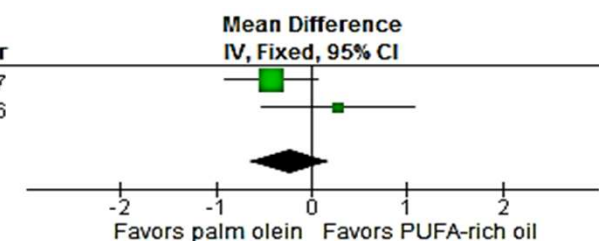
vs MUFA-rich oil

Study or Subgroup	Palm olein			MUFA-rich oil			Weight	Mean Difference IV, Fixed, 95% CI	Year
	Mean	SD	Total	Mean	SD	Total			
Zhang et al. (25) (PE)	3.49	0.92	30	4.32	0.86	30	21.4%	-0.83 [-1.28, -0.38]	1997
Vega-Lopez et al. (28) (CAN)	4.89	1.06	15	4.54	1.06	15	7.5%	0.35 [-0.41, 1.11]	2006
Voon et al. (24) (OO)	3.69	0.9	45	3.63	0.93	45	30.3%	0.06 [-0.32, 0.44]	2011
Fillipou et al. (23) (HOS)	3.52	0.82	41	3.35	0.8	41	35.3%	0.17 [-0.18, 0.52]	2014
Lucci et al. (29) (OO)	5.36	2.48	68	5.34	2.98	77	5.5%	0.02 [-0.87, 0.91]	2016
Total (95% CI)			199			208	100.0%	-0.07 [-0.28, 0.14]	
Heterogeneity: $\chi^2 = 14.40$, $df = 4$ ($P = 0.006$); $I^2 = 72\%$									
Test for overall effect: $Z = 0.67$ ($P = 0.50$)									



vs PUFA-rich oil

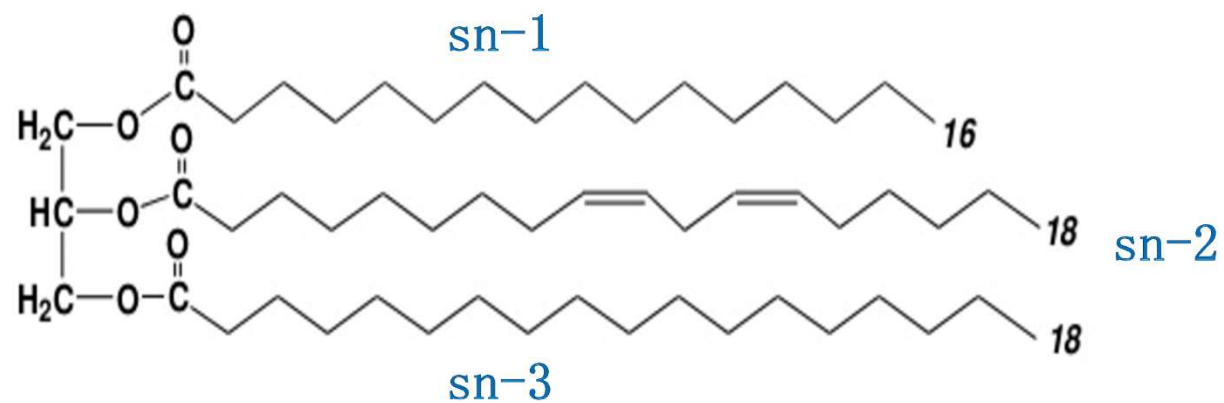
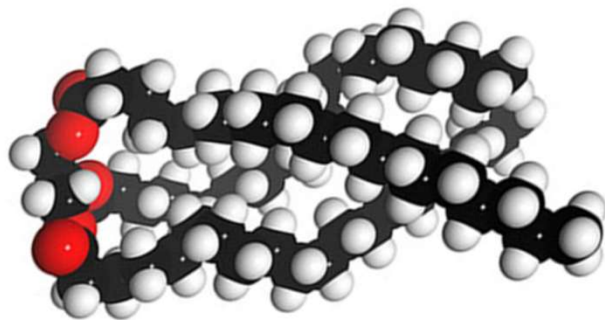
Study or Subgroup	Palm olein			PUFA-rich oil			Weight	Mean Difference IV, Fixed, 95% CI	Year
	Mean	SD	Total	Mean	SD	Total			
Zhang et al. (25) (SBO)	3.49	0.92	30	3.91	1	30	73.0%	-0.42 [-0.91, 0.07]	1997
Vega-Lopez et al. (28) (SBO)	4.89	1.06	15	4.61	1.17	15	27.0%	0.28 [-0.52, 1.08]	2006
Total (95% CI)			45			45	100.0%	-0.23 [-0.65, 0.18]	
Heterogeneity: $\chi^2 = 2.15$, $df = 1$ ($P = 0.14$); $I^2 = 54\%$									
Test for overall effect: $Z = 1.09$ ($P = 0.28$)									



Discussion: Palm olein behaves like an unsaturated oil



Positional Distribution of Triglycerides (TAG)



Structure of TAG

Fats and fatty acids in human nutrition

Report of an expert consultation

ISSN 0254-4725

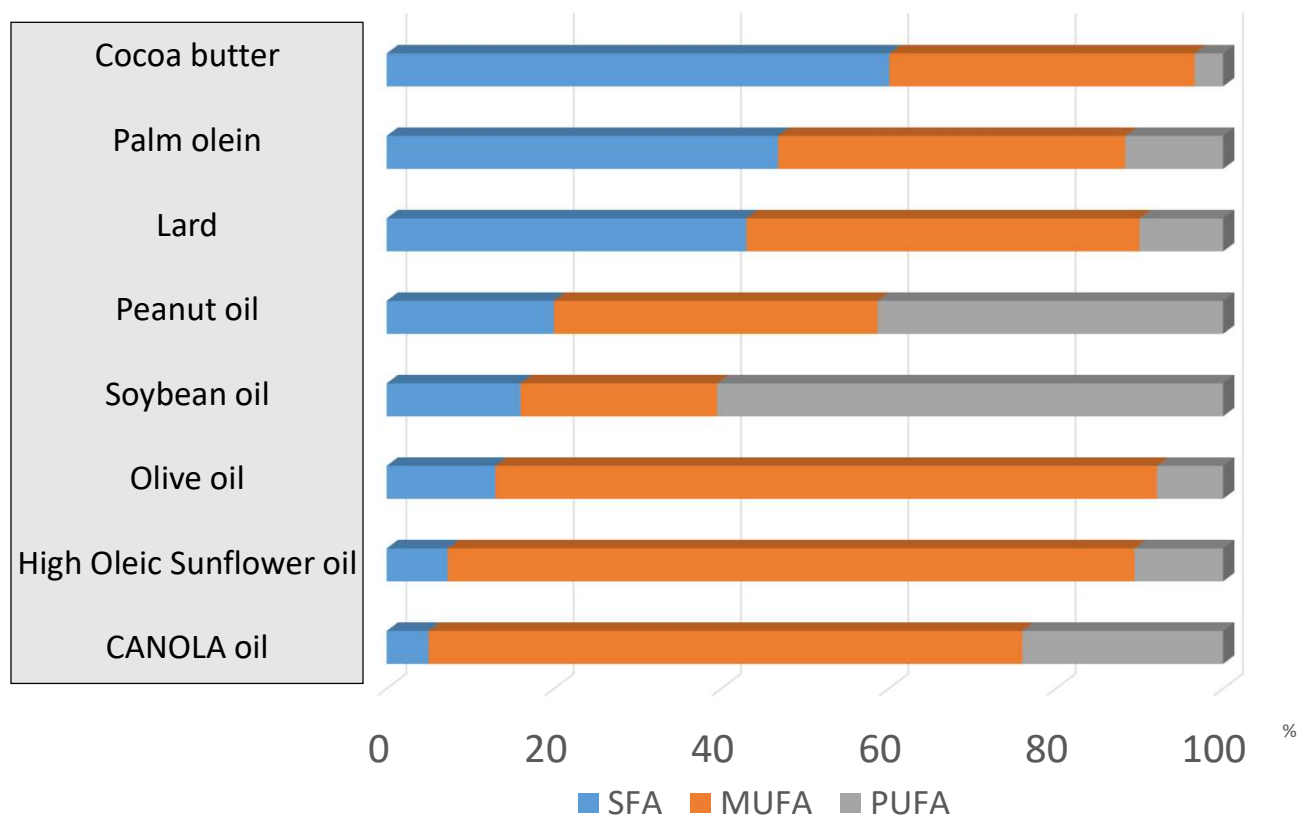
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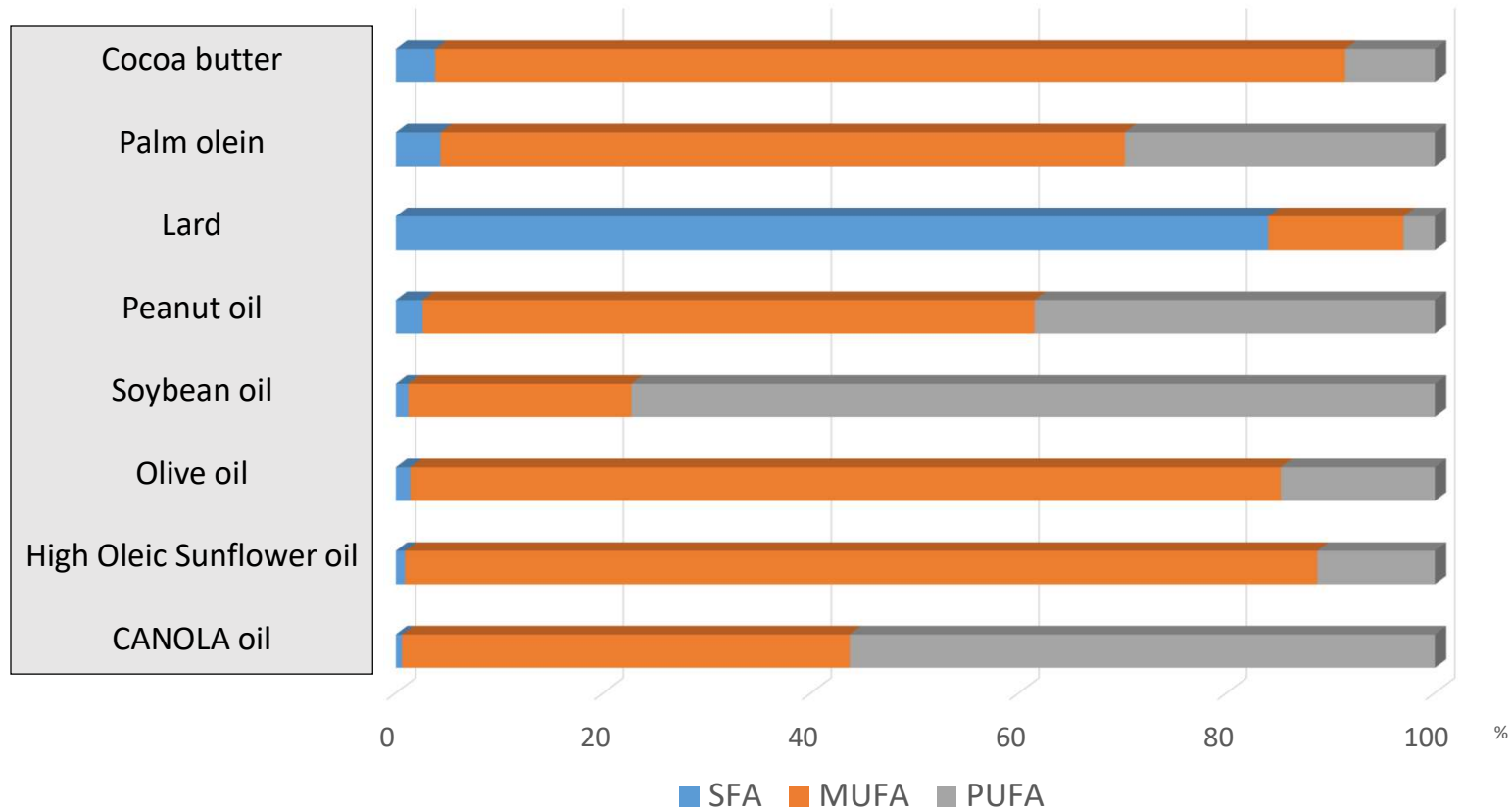
Chapter 10 of the report states that “There is possible evidence to suggest that the TC and LDL-C raising effects of palmitic acid are lower for vegetable than animal sources because it is present predominantly in the sn-1 and sn-3 position as opposed to sn-2 position as in animal fats such as lard”

References cited: Ng et al 1992 JACN; Choudhury et al. 1995 AJCN; Zhang et al. 1997 APJCN

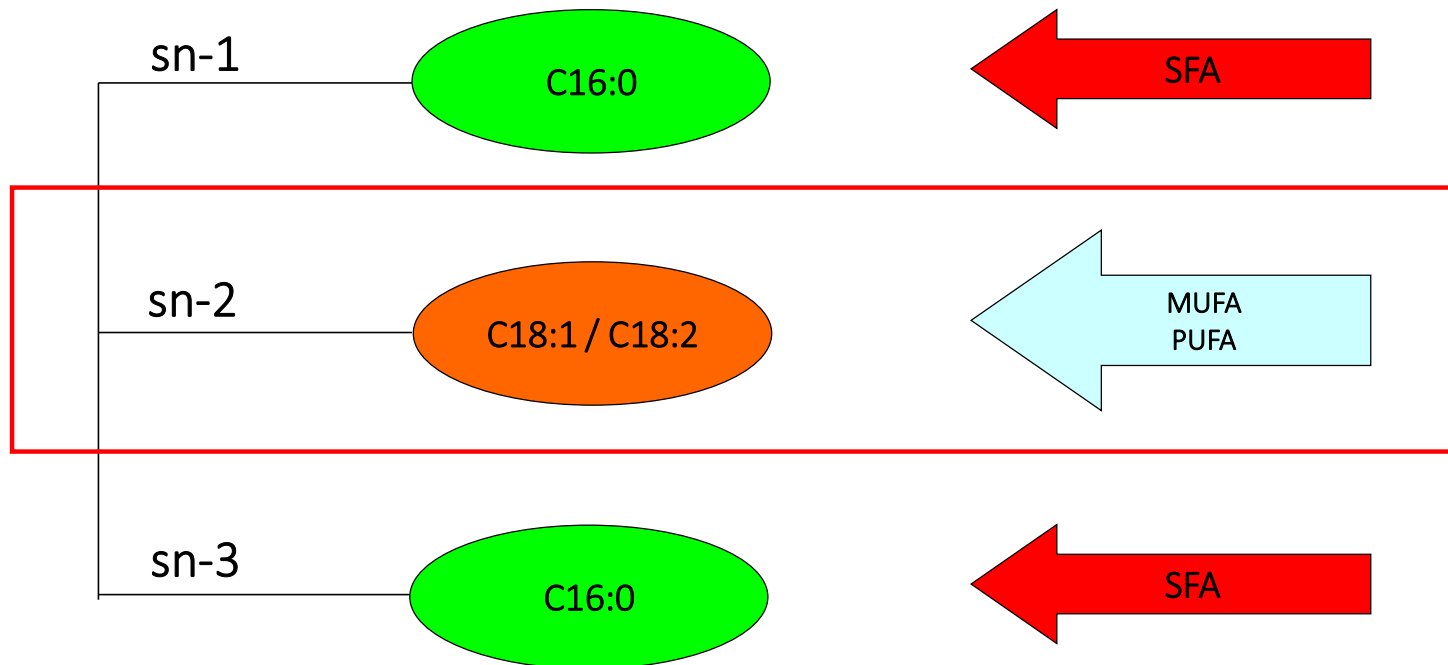
Fatty acid composition of dietary fat/oils



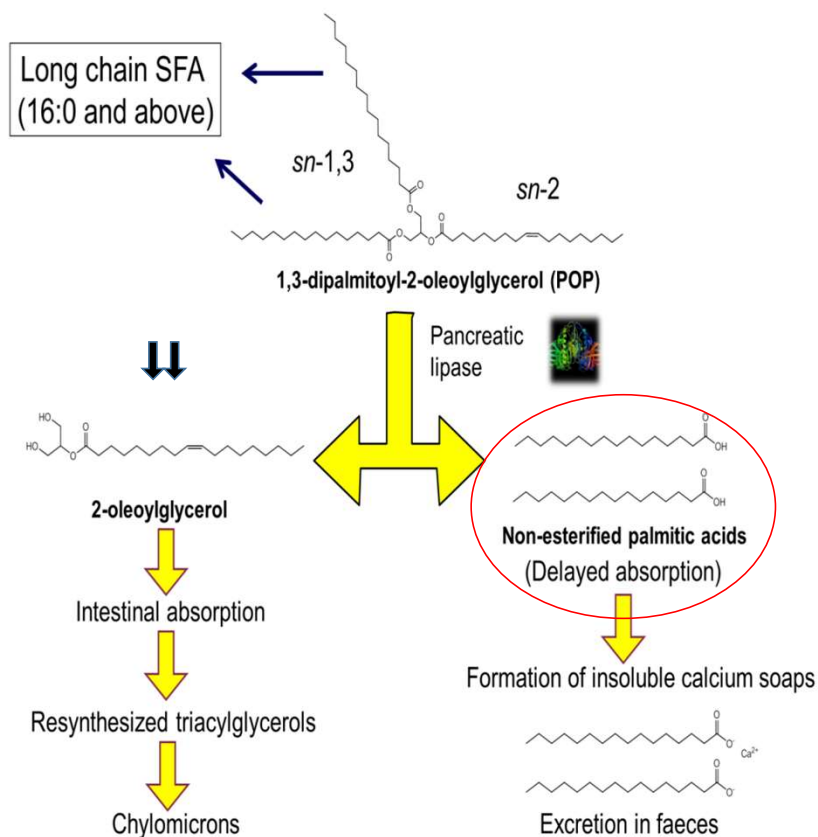
sn-2 Fatty acid composition of dietary fat/oils



Main positional distribution of fatty acids on TAG backbone of palm olein



Palm oil/ olein contains predominantly C18:1 and C18:2 at the sn-2 position



- SFA (mainly palmitic acid) occupy the sn-1, and-3 positions of palm olein.
- The SFA located at the outer stereospecific region will tend to form calcium soap and be excreted into the faeces.
- This is due to its long chain and a high melting point (60-65°C). Similar to MUFA/PUFA-rich vegetable oils, the sn-2 position of palm olein is occupied predominantly by oleic acid.
- When ingested, oleic acid is hydrolyzed in the stomach, absorbed intact as monoglycerides into the blood circulation
- Therefore, palm olein diet containing higher SFA than other liquid vegetable oils, does not affect blood cholesterol and lipid profile adversely when compared to MUFA- or PUFA- rich diet.
- **Fatty acids in the sn-2 position are mostly absorbed by the body whilst the fatty acids in the 1 and 3 positions are mostly excreted as found in the recent human feeding intervention.**

CONCLUSION

- **Palm olein does not behave like a SFA-rich fat** due to its non-cholesterolemic effects in healthy adults whose total fat intake are within the recommended 30-35% energy.
- **The effect of palm olein with other unsaturated vegetable oils**, namely OO, CAN, SBO and HOSF on serum lipid profile in healthy human adults are comparable.



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Advances in Nutrition, nmy122, <https://doi.org/10.1093/advances/nmy122>

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REVIEW



Intake of Palm Olein and Lipid Status in Healthy Adults: A Meta-Analysis

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ABSTRACT

It is not clear whether a saturated fatty acid-rich palm olein diet has any significant adverse effect on established surrogate lipid markers of cardiovascular disease (CVD) risk. We reviewed the effect of palm olein with other oils on serum lipid in healthy adults. We searched in MEDLINE and CENTRAL: Central Register of Controlled Trials from 1975 to January 2018 for randomized controlled trials of ≥ 2 wk intervention that compared the effects of palm olein (the liquid fraction of palm oil) with other oils such as coconut oil, lard, canola oil, high-oleic sunflower oil, olive oil, peanut oil, and soybean oil on changes in serum lipids. Nine studies were eligible and were included, with a total of 533 and 542 subjects on palm olein and other dietary oil diets, respectively. We extracted and compared all the data for serum lipids, such as total cholesterol (TC), LDL cholesterol, HDL cholesterol, triglyceride, and TC/HDL cholesterol ratio. When comparing palm olein with other dietary oils, the overall weighted mean differences for TC, LDL cholesterol, HDL cholesterol, triglycerides, and the TC/HDL cholesterol ratio were -0.10 (95% CI: $-0.30, 0.10$; $P = 0.34$), -0.06 (95% CI: $-0.29, 0.16$; $P = 0.59$), 0.02 (95% CI: $-0.01, 0.04$; $P = 0.20$), 0.01 (95% CI: $-0.05, 0.06$; $P = 0.85$), and -0.15 (95% CI: $-0.43, 0.14$; $P = 0.32$), respectively. Overall, there are no significant differences in the effects of palm olein intake on lipoprotein biomarkers ($P > 0.05$) compared with other dietary oils. However, dietary palm olein was found to have effects comparable to those of other unsaturated dietary oils (monounsaturated fatty acid- and polyunsaturated fatty acid-rich oils) but differed from that of saturated fatty acid-rich oils with respect to the serum lipid profile in healthy adults. *Adv Nutr* 2019;00:1–13.

Keywords: meta-analysis, lipid profile, palm olein, saturated fatty acid, healthy adults

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