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WHAT DOES THE SCIENCE SAY ABOUT SEED OILS?

By Kristina S. Petersen, PhD, FAHA

Edible plant oils are commonly referred to as vegetable oils and include oils derived from vegetables, nuts, seeds, fruits, and cereal grains. The term "seed oil" has recently gained popularity and refers to oils derived from plant seeds. Seed oils, which are high in unsaturated fatty acids, include canola, corn, cottonseed, soybean, sunflower, safflower, grapeseed, and rice bran oil. Social media misinformation about seed oils includes claims that they cause inflammation, type 2 diabetes, and other chronic diseases, and has led to the "anti-seed oil movement". As a result, some consumers have decided to avoid seed oils.

This movement has risen in prominence despite the preponderance of evidence showing no adverse health effects of seed oils or their constituents, and strong evidence demonstrating cardiometabolic health benefits of consuming unsaturated fatty acids.[1-6] This article will review the evidence on the association between fatty acid and seed oil intake on risk factors for major diet-related chronic diseases with a focus on cardiometabolic disease.[7]

Seed oils differ widely in their fatty acid composition (Table 1); however, all are higher in unsaturated fatty acids, including monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), than in saturated fatty acids (SFA). While humans can endogenously synthesize adequate amounts of SFA and MUFA, humans are unable to synthesize the essential omega-6 PUFA linoleic acid (LA) and the essential omega-3 PUFA alpha-linolenic acid (ALA). Therefore, LA and ALA must be consumed to ensure nutrient adequacy. The U.S. recommendations for LA and ALA intake are presented in Table 2. These adequate intake recommendations are based on the U.S. median intake where deficiency is non-existent among healthy individuals.[8]

Table 1: Fatty acid composition of commonly consumed seed oils, animal fats, and tropical oils ordered by saturated fat content.

Category	Fat/Oil	Fatty Acid Composition (g/100 g)				
		Saturated Fat	Monounsaturated Fat	Polyunsaturated Fat		
				Total	LA	ALA
Seed Oils	Canola Oil	6.6	62.6	25.3	17.8	7.5
	Safflower Oil	7.7	71.6	13.8	13.6	0.2
	Sunflower Oil	9.0	63.4	20.7	20.6	0.2
	Grapeseed Oil	9.6	16.1	69.9	69.6	0.1
	Corn Oil	13.4	27.7	52.9	51.9	1.0
	Soybean Oil	14.9	22.1	57.6	50.9	6.6
	Rice Bran Oil	19.7	39.3	35	33.4	1.6
	Cottonseed Oil	25.9	17.8	51.9	51.5	0.2
Animal Fats	Lard	39.2	45.1	11.2	10.2	1.0
	Tallow	49.8	41.8	4	3.1	0.6
	Butter	50.5	23.4	3.0	1.8	1.2
	Ghee	61.9	28.7	3.7	2.2	1.4
Tropical Oils	Palm Oil	49.3	37	9.3	9.1	0.2
	Coconut Oil	82.5	6.3	1.7	1.7	0.0

Data are from USDA FoodData Central (https://fdc.nal.usda.gov/).

Table 2: Adequate intake recommendations for linoleic and alpha-linolenic acid by life stage group.[8]

Life Stage Group	LA		ALA	
	Males	Female	Males	Females
0-6 months	4.4		0.5	
7-12 months	4.6		0.5	
1-3 years	7		0.7	
4-8 years	10		0.9	
9-13 y	12	10	1.2	1.0
14-18 y	16	11	1.6	1.1
19-30 y	17	12	1.6	1.1
31-50 y	17	12	1.6	1.1
51-70 y	14	11	1.6	1.1
>70 y	14	11	1.6	1.1
All Ages				
Pregnancy	13		1.4	
Lactation	13		1.3	

Epidemiological Evidence

Meta-analyses of epidemiological studies show higher intake of omega-6 PUFA, predominately LA, is associated with lower risk of cardiovascular disease (CVD) and type 2 diabetes.[9,10] In addition, higher intake of LA is associated with lower total mortality risk as well as lower risk of mortality from CVD and cancer.[11] In alignment, pooled analyses of observational studies examining biomarkers of omega-6 PUFA intake show higher proportions of LA biomarkers are associated with lower risk of CVD, cardiovascular mortality, ischemic stroke, and type 2 diabetes.[12,13]

Epidemiological evidence relevant to the association between MUFA intake and CVD is less consistent. Studies generally show no association between total MUFA intake and risk of CVD14 or mortality from CVD or cancer.[15] However, higher MUFA intake from plant sources is associated with lower risk of CVD.[14]

Consistent epidemiological evidence also demonstrates that the replacement of SFA with PUFA, predominately LA, is associated with lower risk of CVD events and CVD mortality.[9,16] In addition, replacement of SFA with PUFA is associated with lower risk of mortality from cancer, neurodegenerative diseases, and respiratory diseases.[5]

Clinical Trials

Evidence demonstrates that increased consumption of essential fatty acids is associated with lower risk of cardiovascular disease and type 2 diabetes.

Evidence from clinical trials demonstrates that intake of unsaturated fatty acids as a replacement for SFA reduces the risk of cardiovascular events and improves major risk factors for CVD. The most recent Cochrane Collaboration review, which included 15 randomized controlled trials, examining the effect of SFA replacement, concluded that replacing SFA with PUFA is associated with lower risk of CVD.[17] A similar finding was reported in an American Heart Association Presidential Advisory on dietary fats.[5] A meta-analysis of the core randomized controlled trials showed that replacing SFA with PUFA reduced CVD risk by 29%.

Strong and consistent evidence from clinical trials shows that consuming unsaturated fatty acids instead of SFA improves atherogenic lipoproteins. A systematic review and meta-regression that included 84 randomized controlled trials showed that isocalorically replacing SFA with PUFA or MUFA reduced total cholesterol, LDL-cholesterol, and apolipoprotein B to a clinically relevant extent.[18] In alignment, clinical trial evidence shows that intake of canola,[19,20] corn,[21-23] cottonseed,[24,25] soybean,[26] sunflower,[27,28] safflower,[29,30] and rice bran oil[31] improves atherogenic lipoproteins. Finally, a network meta-analysis of randomized controlled trials examining direct and indirect evidence on the effects of 13 oils and solid fats (safflower, sunflower, canola, hempseed, flaxseed, corn, olive, soybean, palm, and coconut oils as well as beef fat, lard, and butter), showed that replacement of 10% of energy from butter with an equivalent amount of safflower, sunflower, canola,

olive, flaxseed, corn, or soybean oil lowered LDL-cholesterol by 10–16 mg/dl.[32] In summary, replacement of dietary sources of SFA with oils rich in PUFA and MUFA consistently improves atherogenic lipoproteins.

Evidence indicates unsaturated fatty acids may help reduce risk of type 2 diabetes
Evidence from clinical trials also demonstrates that replacing SFA with PUFA improves glucose-insulin homeostasis. A meta-analysis of 102 controlled-feeding trials showed that replacing SFA with PUFA improved fasting glucose, HbA1C, C-peptide, and Homeostatic Model Assessment for Insulin Resistance (HOMA-IR).[33]

Evidence shows no effects or reduced inflammation.
Findings from clinical trials also show that intake of omega-6 PUFA, particularly LA, does not promote inflammation or oxidative stress.[34-37] A systematic review and meta-analysis that included 30 randomized controlled trials showed that higher intake of LA did not increase markers of inflammation including tumor necrosis factor-α, interleukin-6, adiponectin, monocyte chemoattractant protein 1, or C-reactive protein.[34] Similarly, clinical evidence shows no effect of omega-6 PUFA on markers of oxidative stress including oxidized LDL cholesterol[37] or markers of lipid peroxidation included F-2 isoprostanes.[36]

Recommended Intake

Guidelines for general health and chronic disease prevention focus on following a healthy dietary pattern throughout life.[38,39] Healthy dietary patterns emphasize minimally processed fruits, vegetables, whole grains, healthful protein sources (seafood, legumes, soy foods, nuts, and seeds), and liquid non-tropical vegetable oils. These patterns are also low in sources of saturated fats, added sugars, and sodium. To limit sources of SFA, it is recommended to replace rich sources of SFA, such as butter, tallow, lard, palm and coconut oils, duck fat, and ghee with vegetable oils including seed oils.

Summary

Strong evidence supports consuming unsaturated fatty acids, particularly PUFA, instead of SFA to reduce the risk of CVD and type 2 diabetes. It is recommended that non-tropical liquid vegetable oils, including seed oils, be consumed as part of healthy dietary patterns. Vegetable oils should be used as a replacement for rich sources of SFA including butter, tallow, lard, palm and coconut oils, duck fat, and ghee.

ABOUT THE AUTHORS

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IMPACT OF SOYBEAN OIL ON METABOLIC DYSFUNCTION-ASSOCIATED STEATOTIC LIVER DISEASE (MASLD) AND CARDIOMETABOLIC OUTCOMES

By Martha Ann Belury, PhD, RDN

Approximately one in four U.S. adults have metabolic dysfunction-associated steatotic liver disease (MASLD), formerly called non-alcoholic fatty liver disease (NAFLD), a condition that usually accompanies central obesity. NAFLD is tightly linked with hepatic insulin resistance and is therefore a major risk factor for metabolic syndrome and type 2 diabetes. It is mis-considered the "hepatic manifestation" for cardiometabolic diseases. Therapies that reduce ectopic liver fat (defined as an abnormal accumulation of fat within the liver, where fat is not typically stored in significant amounts) also reduce risk for cardiometabolic

diseases; yet, other than weight loss, therapies that effectively and safely reduce ectopic lipid accumulation in the liver remain elusive.

Diets high in saturated fat or high fructose corn syrup are known to increase the risk of developing NAFLD. In contrast, diets rich in long chain omega-3 fatty acids have been tested for lowering liver fat but with varied success.[1] There is intriguing speculation that the essential omega-6 fatty acid linoleic acid (LA; 18:2n6) may retard lipid accumulation in the liver.[2] However, to our knowledge, there have not been any studies to determine if supplementing the diet with LA will therapeutically reduce fat content in the liver of people with NAFLD. Americans consume 7-8% of their energy intake from LA[3,4] and the Dietary Guidelines for Americans recommends LA intake to be 5-10% of energy.[5]

Linoleic acid and health

Observational studies

Dietary LA intake is inversely associated with mortality in women[6] and with risk of type 2 diabetes mellitus (T2DM) in adults.[7] Also, blood biomarkers of LA intake are inversely correlated with total and coronary heart disease mortality,[8] incidences of diabetes[9] and NAFLD,[10] visceral and liver fat,[11] and markers of inflammation.[12] LA biomarkers are positively associated with lean mass in men and women[12] and negatively associated with adipose accumulation in muscle of older adults.[13-16]

Intervention studies

Compared to a diet high in saturated fat, a diet high in LA has been shown to have beneficial effects in multiple studies.[17-21] In dietary intervention trials, supplementing the diet with a LA-rich oil increases lean mass[15] and HDL-cholesterol,[14] and decreases trunk fat,[15] C-reactive protein (a marker of inflammation),[14] glucose,[14,15] and the cardioprotective cytokine adiponectin.[16] Adults who consumed a diet rich in LA saw improvements in insulin sensitivity and LDL-cholesterol when compared to the same adults who consumed a diet high in saturated fat.[18] In healthy adults, a eucaloric diet rich in LA decreased fat mass, total cholesterol, and LDL-cholesterol after 16 weeks compared to a diet rich in saturated fat.[20]

LA and liver health

In a study where abdominally obese adults consumed a 10-week isocaloric diet rich in LA vs. saturated fat, adults consuming the LA-rich diet had decreased liver fat accumulation and markers of inflammation which was not found in the saturated fat diet group.[17] In agreement, in an overfeeding trial in which non-obese adults were fed muffins rich in saturated fat or rich in LA, there was an in increase in liver fat and visceral fat accumulation when consuming the former but not the latter.[19,21]

Oil derived from conventional soybeans contains approximately 51-55% LA. Therefore, the many benefits of LA on body composition, lipoprotein metabolism, and insulin sensitivity strongly suggest that that LA-fortified diets using soybean oil will reduce hepatic lipid accumulation in people with MASLD. Studies to evaluate the role of soybean oil fortification of diets to reduce ectopic lipids in the liver are underway.

ABOUT THE AUTHOR

Martha Anne Belury, PhD, RDN, is a translational nutrition scientist with more than 25 years of experience working to identify the role of dietary fatty acids in inflammation and metabolism in human health and disease. Before joining the faculty at Ohio State University, she earned a PhD in biological sciences from the University of Texas and served on faculties at Montana State University and Purdue University.

PRACTICAL TIPS FOR CONSUMING FATS AND OILS

By Michelle Routhenstein, MS, RD, CDCES, CDN

The type of dietary fat consumed may affect the risk of coronary artery disease. This article explains the different types of fats, how they affect blood cholesterol levels, and how to properly counsel patients and clients on which fats to consume and which to replace to improve heart health.

A Breakdown of Fat Types

Trans fats are typically made through partial hydrogenation, an industrial process where hydrogen is added to make liquid fat solid at room temperature. Partially hydrogenated fats have a longer shelf life than oils high in unsaturated fatty acids. However, trans fatty acids increase circulating levels of low-density lipoprotein (LDL) cholesterol and lower high-density lipoprotein (HDL) cholesterol levels which contributes to cardiovascular disease risk.[1]

On a nutrition facts label, "total fat", "saturated fat", and "trans fat" are required to be displayed. However, if a food contains less than 0.5 grams of trans fat per serving, it can appear as 0 grams of trans fat.[2]

Source: U.S. Food and Drug Administration

In 2015, the FDA took its first significant step to reduce artificial trans fat in the food supply by determining that partially hydrogenated oils (PHOs) are no longer "Generally Recognized as Safe" (GRAS) due to their adverse health effects. The FDA established January 1, 2021, as the final compliance date to allow manufacturers time to reformulate products. In 2023, the FDA implemented a direct final rule to eliminate PHOs from processed foods to further reduce trans-fat levels in packaged foods.[3] Many manufacturers have replaced trans fats with saturated fats, such as palm oil, to improve shelf stability and achieve a solid texture at room temperature.

Saturated fat do not contain carbon-carbon double bonds and are typically solid at room temperature. Most types of saturated fat increase circulating levels of LDL cholesterol. Saturated fats are typically found in butter, cheese, meat, whole fat dairy, and some plant oils like coconut and palm oil.

Unsaturated fat contains one or more double bonds between carbon atoms and is typically liquid at room temperature. Unsaturated fats include monounsaturated (MUFA) and polyunsaturated (PUFA) fats. Their distinction is based on the number of bonds in their chemical structure. Unsaturated fats lower cholesterol absorption and reduce overall cholesterol levels by increasing the activity of LDL receptors in the liver, which helps clear LDL particles (lipoproteins carrying cholesterol) from the bloodstream.[4] Unsaturated fats are commonly found in fatty fish, nuts, seeds, and plant-based oils like soybean, canola, avocado, and olive oil. If the nutrition facts label does not include MUFA and PUFA facts, consumers can calculate those manually by subtracting the saturated and trans fats from

the total fat grams. The remaining fat grams are unsaturated fats.

Recommendations for Patients and Clients

The U.S. Dietary Guidelines, World Health Organization (WHO), and The American Heart Association (AHA) recommend limiting daily saturated fat intake. AHA recommends limiting saturated fat to less than 6% of total daily calories. For someone consuming a 2,000-calorie diet, this is about 120 calories, equating to about 13 grams of saturated fat daily. This target may be challenging to meet without honing into the grams of saturated fat listed on nutrition labels.

Research shows that the greatest benefit may be achieved by not only removing saturated fat but also replacing it with unsaturated fat (MUFA and PUFA). This replacement may help improve cholesterol levels, reduce inflammation, and lower the risk of heart disease.[5]

Consider these swaps from sources of saturated fat to unsaturated fat that can improve LDL cholesterol and cardiovascular disease risk:

Saturated Fat	Unsaturated Fat
1 tablespoon butter 7 grams of saturated fat 3 grams of unsaturated fat	**1 tablespoon soybean oil** 2 grams of saturated fat 11 grams of unsaturated fat
1 tablespoon coconut oil 11 grams of saturated fat 1 gram of unsaturated fat	**1 tablespoon olive oil** 2 grams of saturated fat 11 grams of unsaturated fat
1 beef stick 6 grams of saturated fat 7 grams of unsaturated fat	**½ cup edamame** 0.5 grams of saturated fat 3.5 grams of unsaturated fat
3.5 ounces rib eye steak, uncooked 8 grams of saturated fat 8 grams of unsaturated fat	**3.5 ounces salmon, uncooked** 3 grams of saturated fat 8 grams of unsaturated fat
2 tablespoons cream cheese 5 grams of saturated fat 2 grams of unsaturated fat	**1/2 small avocado, mashed** 2 grams of saturated fat 12 grams of unsaturated fat
1 cheddar cheese stick 5 grams of saturated fat 2 grams of unsaturated fat	**1 ounce almonds** 3.9 grams of saturated fat 13 grams of unsaturated fat

Fat plays an important role in our health and consumption of fat is necessary for energy, cellular function, nutrient and carotenoid absorption, and hormone regulation. Fat should be looked at as a part of a whole balanced diet that contains complex carbohydrates and lean proteins.

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Michelle Routhenstein, MS, RD, CDCES, CDN, is the owner of Entirely Nourished and specializes in nutrition counseling for heart disease prevention and management. She uses a science-based approach to enhance heart function and reduce cardiometabolic risks. Michelle is a recognized expert and serves on multiple medical advisory boards.

REFERENCES

WHAT DOES THE SCIENCE SAY ABOUT SEED OILS?

1. Petersen KS, Maki KC, Calder PC, Belury MA, Messina M, Kirkpatrick CF, et al. Perspective on the health effects of unsaturated fatty acids and commonly consumed plant oils high in unsaturated fat. British Journal of Nutrition. 2024;(doi:10.1017/S0007114524002459).
2. Jackson KH, Harris WS, Belury MA, Kris-Etherton PM, Calder PC. Beneficial effects of linoleic acid on cardiometabolic health: an update. Lipids Health Dis. 2024;23(1):296.
3. Maki KC, Eren F, Cassens ME, Dicklin MR, Davidson MH. ω-6 Polyunsaturated fatty acids and cardiometabolic health: current evidence, controversies, and research gaps. Advances in Nutrition. 2018;9(6):688–700.
4. Harris WS, Mozaffarian D, Rimm E, Kris-Etherton P, Rudel LL, Appel LJ, et al. Omega-6 fatty acids and risk for cardiovascular disease: a science advisory from the American Heart Association. Circulation. 2009;119(6):902–7.
5. Sacks FM, Lichtenstein AH, Wu JHY, Appel LJ, Creager MA, Kris-Etherton PM, et al. Dietary Fats and Cardiovascular Disease: A Presidential Advisory From the American Heart Association. Circulation. 2017;136(3):e1–23.
6. Wang DD. Dietary n-6 polyunsaturated fatty acids and cardiovascular disease: Epidemiologic evidence. Prostaglandins Leukot Essent Fatty Acids. 2018;135:5–9.
7. Micha R, Peñalvo JL, Cudhea F, Imamura F, Rehm CD, Mozaffarian D. Association between dietary factors and mortality from heart disease, stroke, and type 2 diabetes in the United States. JAMA. 2017;317(9):912–24.
8. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. National Academy Press, Washington, DC; 2005.
9. Farvid MS, Ding M, Pan A, Sun Q, Chiuve SE, Steffen LM, et al. Dietary linoleic acid and risk of coronary heart disease: a systematic review and meta-analysis of prospective cohort studies. Circulation. 2014;130(18):1568–78.
10. Mousavi SM, Jalilpiran Y, Karimi E, Aune D, Larijani B, Mozaffarian D, et al. Dietary intake of linoleic acid, its concentrations, and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of prospective cohort studies. Diabetes Care. 2021;44(9):2173–81.
11. Li J, Guasch-Ferré M, Li Y, Hu FB. Dietary intake and biomarkers of linoleic acid and mortality: systematic review and meta-analysis of prospective cohort studies. Am J Clin Nutr. 2020;112(1):150–67.
12. Wu JHY, Marklund M, Imamura F, Tintle N, Korat AVA, De Goede J, et al. Omega-6 fatty acid biomarkers and incident type 2 diabetes: pooled analysis of individual-level data for 39 740 adults from 20 prospective cohort studies. Lancet Diabetes Endocrinol. 2017;5(12):965–74.
13. Marklund M, Wu JHY, Imamura F, Del Gobbo LC, Fretts A, de Goede J, et al. Biomarkers of dietary omega-6 fatty acids and incident cardiovascular disease and mortality: an individual-level pooled analysis of 30 cohort studies. Circulation. 2019;139(21):2422–36.
14. Schwingshackl L, Hoffmann G. Monounsaturated fatty acids, olive oil and health status: a systematic review and meta-analysis of cohort studies. Lipids Health Dis. 2014;13:1–15.
15. Lotfi K, Salari-Moghaddam A, Yousefinia M, Larijani B, Esmaillzadeh A. Dietary intakes of monounsaturated fatty acids and risk of mortality from all causes, cardiovascular disease and cancer: A systematic review and dose-response meta-analysis of prospective cohort studies. Ageing Res Rev [Internet]. 2021;72:101467. Available from: https://www.sciencedirect.com/science/article/pii/S1568163721002142
16. Jakobsen MU, O'Reilly EJ, Heitmann BL, Pereira MA, Bälter K, Fraser GE, et al. Major types of dietary fat and risk of coronary heart disease: a pooled analysis of 11 cohort studies12. Am J Clin Nutr [Internet]. 2009;89(5):1425–32. Available from: https://www.sciencedirect.com/science/article/pii/S0002916523238034
17. Hooper L, Martin N, Jimoh OF, Kirk C, Foster E, Abdelhamid AS. Reduction in saturated fat intake for cardiovascular disease. Cochrane Database of Systematic Reviews. 2020;5(5):CD011737.
18. Mensink RP. Effects of saturated fatty acids on serum lipids and lipoproteins: a systematic review and regression analysis. Geneva: World Health Organization; 2016.
19. Ghobadi S, Hassanzadeh-Rostami Z, Mohammadian F, Zare M, Faghih S. Effects of canola oil consumption on lipid profile: A systematic review and meta-analysis of randomized controlled clinical trials. J Am Coll Nutr. 2019;38(2):185–96.
20. Amiri M, Raeisi-Dehkordi H, Sarrafzadegan N, Forbes SC, Salehi-Abargouei A. The effects of Canola oil on cardiovascular risk factors: A systematic review and meta-analysis with dose-response analysis of controlled clinical trials. Nutrition, Metabolism and Cardiovascular Diseases. 2020;30(12):2133–45.
21. Maki KC, Lawless AL, Kelley KM, Kaden VN, Geiger CJ, Palacios OM, et al. Corn oil intake favorably impacts lipoprotein cholesterol, apolipoprotein and lipoprotein particle levels compared with extra-virgin olive oil. Eur J Clin Nutr. 2017;71(1):33.
22. 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;148(10):1556–63.
23. Maki KC, Lawless AL, Kelley KM, Kaden VN, Geiger CJ, Dicklin MR. Corn oil improves the plasma lipoprotein lipid profile compared with extra-virgin olive oil consumption in men and women with elevated cholesterol: results from a randomized controlled feeding trial. J Clin Lipidol. 2015;9(1):49–57.
24. Polley KR, Oswell NJ, Pegg RB, Paton CM, Cooper JA. A 5-day high-fat diet rich in cottonseed oil improves cholesterol profiles and triglycerides compared to olive oil in healthy men. Nutrition Research. 2018;60:43–53.
25. Prater MC, Scheurell AR, Paton CM, Cooper JA. Blood Lipid Responses to Diets Enriched with Cottonseed Oil Compared With Olive Oil in Adults with High Cholesterol in a Randomized Trial. J Nutr. 2022;152(9):2060–71.
26. Baer DJ, Henderson T, Gebauer SK. Consumption of high oleic soybean oil improves lipid and lipoprotein profile in humans compared to a palm oil blend: a randomized controlled trial. Lipids. 2021;56(3):313–25.
27. Perez-Jimenez F, Espino A, Lopez-Segura F, Blanco J, Ruiz-Gutierrez V, Prada JL, et al. Lipoprotein concentrations in normolipidemic males consuming oleic acid-rich diets from two different sources: olive oil and oleic acid-rich sunflower oil. Am J Clin Nutr. 1995;62(4):769–75.
28. Wardlaw GM, Snook JT. Effect of diets high in butter, corn oil, or high-oleic acid sunflower oil on serum lipids and apolipoproteins in men. Am J Clin Nutr. 1990;51(5):815–21.
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;20(4):345–51. Reiser R, Probstfield JL, Silvers A, Scott LW, Shorney ML, Wood RD, et al. Plasma lipid and lipoprotein response of humans to beef fat, coconut oil and safflower oil. Am J Clin Nutr. 1985;42(2):190–7.
30. Jolfaie NR, Rouhani MH, Surkan PJ, Siassi F, Azadbakht L. Rice bran oil decreases total and LDL cholesterol in humans: a systematic review and meta-analysis of randomized controlled clinical trials. Hormone and Metabolic Research. 2016;48(07):417–26.
31. Schwingshackl L, Bogensberger B, Benčič A, Knüppel S, Boeing H, Hoffmann G. Effects of oils and solid fats on blood lipids: a systematic review and network meta-analysis. J Lipid Res. 2018;59(9):1771–82.
32. Imamura F, Micha R, Wu JHY, de Oliveira Otto MC, Otite FO, Abioye AI, et al. Effects of saturated fat, polyunsaturated fat, monounsaturated fat, and carbohydrate on glucose-insulin homeostasis: a systematic review and meta-analysis of randomised controlled feeding trials. PLoS Med. 2016;13(7):e1002087.
33. Su H, Liu R, Chang M, Huang J, Wang X. Dietary linoleic acid intake and blood inflammatory markers: a systematic review and meta-analysis of randomized controlled trials. Food Funct. 2017;8(9):3091–103.

34. Johnson GH, Fritsche K. Effect of dietary linoleic acid on markers of inflammation in healthy persons: a systematic review of randomized controlled trials. J Acad Nutr Diet. 2012;112(7):1029–41.
35. Da Silva MS, Bilodeau JF, Julien P, Rudkowska I. Dietary fats and F2-isoprostanes: A review of the clinical evidence. Crit Rev Food Sci Nutr. 2017;57(18):3929–41.
36. Sanders TAB. Omega-6 Fatty Acids and Cardiovascular Disease. Circulation. 2019 May 21;139(21):2437–9.
37. U.S. Department of Agriculture, U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. 9th Edition [Internet]. 2020 [cited 2021 Jan 1]. Available from: www.dietaryguidelines.gov
38. Lichtenstein AH, Appel LJ, Vadiveloo M, Hu FB, Kris-Etherton PM, Rebholz CM, et al. 2021 Dietary Guidance to Improve Cardiovascular Health: A Scientific Statement From the American Heart Association. Circulation. 2021;CIR-0000000000001031.

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1. Sabinari, I. et al. Influence of Lipid Class Used for Omega-3 Fatty Acid Supplementation on Liver Fat Accumulation in MASLD. Physiol Res 73, S295-s320, doi:10.33549/physiolres.935396 (2024).
2. Zhuang, P. et al. Circulating fatty acids and risk of severe non-alcoholic fatty liver disease in the UK biobank: a prospective cohort of 116 223 individuals. Food Funct 15, 10527-10538, doi:10.1039/d4fo01182a (2024).
3. Harris, W., Mozaffarian, D, Rimm, E, Kris-Etherton, P, Rudel, LL, Appel, LJ, Engler, MM, Engler, MB, Sacks, F,. Omega-6 fatty acids and risk for cardiovascular disease: a science advisory from the American Heart Association Nutrition Subcommittee of the Council on Nutrition, Physical Activity, and Metabolism; Council on Cardiovascular Nursing; and Council on Epidemiology and Prevention. Circulation 119, 902-907 (2009).
4. U.S. Department of Agriculture, Agricultural Research Service, Food Surveys Research Group, 2021. What We Eat In America. https://www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-research-center/food-surveys-research-group/.
5. Snetselaar, L. G., de Jesus, J. M., DeSilva, D. M. & Stoody, E. E. Dietary Guidelines for Americans, 2020-2025: Understanding the Scientific Process, Guidelines, and Key Recommendations. Nutr Today 56, 287-295, doi:10.1097/nt.0000000000000512 (2021).
6. Wang, D. D. et al. Association of Specific Dietary Fats With Total and Cause-Specific Mortality. JAMA Intern Med, doi:10.1001/jamainternmed.2016.2417 (2016).
7. Zong, G., Liu, G, Willett, WC, Wanders, AJ, Alssema, M, Zock, PL, Hu, FB, Sun, Q. Associations Between Linoleic Acid Intake and Incident Type 2 Diabetes Among U.S. Men and Women. Diabetes Care 42, 1406-1413 (2019).
8. Wu, J., Lemaitre, RN, King, IB, Song, X, Psaty, BM, Siscovick, DS, Mozaffarian, D. Circulating omega-6 polyunsaturated fatty acids and total and cause-specific mortality: the Cardiovascular Health Study. Circulation 130, 1245-1253 (2014).
9. Wang, L., Folsom, A. R., Zheng, Z. J., Pankow, J. S. & Eckfeldt, J. H. Plasma fatty acid composition and incidence of diabetes in middle-aged adults: the Atherosclerosis Risk in Communities (ARIC) Study. Am J Clin Nutr 78, 91-98, doi:10.1093/ajcn/78.1.91 (2003).
10. Puri, P., Wiest, MM, Cheung, O, Mirshahi, F, Sargeant, C, Min, HK, Contos, MJ, Sterling, RK, Fuchs, M, Zhou, H, Watkins, SM, Sanyal, AJ. The plasma lipidomic signature of nonalcoholic steatohepatitis. Hepatology 50, 1827-1838 (2009).
11. Rosqvist, F., Bjermo, H, Kullberg, J, Johansson, L, Michaëlsson, K, Ahlström, H, Lind, L, Risérus, U. Fatty acid composition in serum cholesterol esters and phospholipids is linked to visceral and subcutaneous adipose tissue content in elderly individuals: a cross-sectional study. Lipids Health Disease 16, doi:10.1186/s12944-017-0445-2 (2017).
12. Belury, M., Cole, RM, Bailey, BE, Ke, JY, Andridge, RR, Kiecolt-Glaser, JK,. Erythrocyte linoleic acid, but not oleic acid, is associated with improvements in body composition in men and women. Mol Nutr Food Res 60, 1206-1212 (2016).
13. Reinders, I., Song, X, Visser, M, Eiriksdottir, G, Gudnason, V, Sigurdsson, S, Aspelund, T, Siggeirsdottir, K, Brouwer, IA, Harris, TB, Murphy, RA. Plasma phospholipid PUFAs are associated with greater muscle and knee extension strength but not with changes in muscle parameters in older adults. The Journal of nutrition. 145, 105-112 (2015).
14. Asp, M., Collene, AL, Norris, LE, Cole, RM, Stout, MB, Tang, SY, Hsu, JC, Belury, MA,. Time-dependent effects of safflower oil to improve glycemia, inflammation and blood lipids in obese, post-menopausal women with type 2 diabetes: a randomized, double-masked, crossover study. Clinical Nutrition 30, 443-449 (2011).
15. Norris, L., Collene, AL, Asp, ML, Hsu, JC, Liu, LF, Richardson, JR, Li, D, Bell, D, Osei, K, Jackson, RD, Belury, MA. Comparison of dietary conjugated linoleic acid with safflower oil on body composition in obese postmenopausal women with type 2 diabetes mellitus. Am J Clin Nutr 90, 468-476, doi:10.3945/ajcn.2008.27371 (2009).
16. Cole, R. M. et al. Linoleic Acid-Rich Oil Supplementation Increases Total and High-Molecular-Weight Adiponectin and Alters Plasma Oxylipins in Postmenopausal Women with Metabolic Syndrome. Curr Dev Nutr 4, nzaa136, doi:10.1093/cdn/nzaa136 (2020).
17. Bjermo, H., Iggman, D, Kullberg, J, Dahlman, I, Johansson, L, Persson, L, Berglund, J, Pulkki, K, Basu, S, Uusitupa, M, Rudling, M, Arner, P, Cederholm, T, Ahlström, H, Risérus, U,. Effects of n-6 PUFAs compared with SFAs on liver fat, lipoproteins, and inflammation in abdominal obesity: a randomized controlled trial. Am J Clini Nutr. 95, 1003-1012 (2012).
18. Summers, L., Fielding, BA, Bradshaw, HA, Ilic, V, Beysen, C, Clark, ML, Moore, NR, Frayn, KN. Substituting dietary saturated fat with polyunsaturated fat changes abdominal fat distribution and improves insulin sensitivity. Diabetologia 45, 369-377 (2002).
19. Rosqvist, F., Iggman, D, Kullberg, J, Cedernaes, J, Johansson, HE, Larsson, A, Johansson, L, Ahlström, H, Arner, P, Dahlman I, Risérus, U. Overfeeding polyunsaturated and saturated fat causes distinct effects on liver and visceral fat accumulation in humans. Diabetes 63, 2356-2368 (2014).
20. Stonehouse, W. et al. Eucaloric diets enriched in palm olein, cocoa butter, and soybean oil did not differentially affect liver fat concentration in healthy participants: a 16-week randomized controlled trial. Am J Clin Nutr 113, 324-337, doi:10.1093/ajcn/nqaa347 (2021).
21. Rosqvist, F., Kullberg, J, Ståhlman, M, Cedernaes, J, Heurling, K, Johansson, HE, Iggman, D, Wilking, H, Larsson, A, Eriksson, O, Johansson, L, Straniero, S, Rudling, M, Antoni, G, Lubberink, M, Orho-Melander, M, Borén, J, Ahlström, H, Risérus, U. Overeating Saturated Fat Promotes Fatty Liver and Ceramides Compared With Polyunsaturated Fat: A Randomized Trial. J Clin Endocrinol Metab 104, 6207-6219 (2019). 10. Monteiro CA, Cannon G, Lawrence M, Costa Louzada Md, Pereira Machado P. Ultra-processed foods, diet quality, and health using the NOVA classification system. Rome: FAO. 2019;48.

PRACTICAL TIPS FOR CONSUMING FATS AND OILS

1. Iqbal MP. Trans fatty acids - A risk factor for cardiovascular disease. Pak J Med Sci. 2014 Jan;30(1):194-7. doi: 10.12669/pjms.301.4525. PMID: 24639860; PMCID: PMC3955571. https://pmc.ncbi.nlm.nih.gov/articles/PMC3955571/.
2. U.S. Food and Drug Administration. (n.d.). Small entity compliance guide: Trans fatty acids, nutrition labeling, and nutrient content claims. U.S. Department of Health and Human Services. Retrieved November 7, 2024, from https://www.fda.gov/regulatory-information/search-fda-guidance-documents/small-entity-compliance-guide-trans-fatty-acids-nutrition-labeling-nutrient-content-claims-and
3. U.S. Food and Drug Administration. Final Determination Regarding Partially Hydrogenated Oils. Publication date: 06/17/2015. https://www.federalregister.gov/d/2015-14883.
4. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. https://www.ahajournals.org/doi/10.1161/cir.0000000000000678.
5. Sacks, Frank M. et al. Dietary Fats and Cardiovascular Disease: A Presidential Advisory From the American Heart Association. AHA Journal. Volume 136, Number 3. https://www.ahajournals.org/doi/full/10.1161/cir.0000000000000510.

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