Fats and oils: The health concerns and issues- A review

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ABSTRACT
Hydrogenated vegetable oils became popular for cooking in 1950s. Soon it became established that eating food cooked in hydrogenated oils (trans fats) could be the risk factors for cardio vascular diseases. Refined oils were recommended for cooking. It was believed that refined oils are rich in monounsaturated fatty acids (MUFA or omega-6) and will help maintain low cholesterol levels. Further research proved that omega-6 rich diet reduced HDL (High density lipoprotein) as well as LDL (low density lipoprotein). World health organization recommended that we should increase omega-3 i.e. poly unsaturated fatty acids (PUFA). PUFA help in keeping healthy HDL/LDL ratio. A number of reports also suggested that natural saturated fatty acids (nSFA) were not risk factors for coronary heart disease (CHD). In this mini review an account of developments concerning these issues has been presented.

Key words: Coronary heart disease, HDL, LDL, MUFA, PUFA.

A low fat diet was recommended world over for a healthy heart for the last six to seven decades. Refined oils were one of the recommended oils for cooking as these oils were low in saturated fatty acids and rich in unsaturated fatty acids. Dalda ghee (Hydrogenated vegetable oil) became a household name as an alternative to desi ghee (clarified butter fat) in 1950s in India. The ghee was thermally stable and for its appearance like desi ghee it became very popular. One of the famous advertisements in print media carried the tag line ’mothers who care cook in dalda’. Soon the bad effects of hydrogenated fatty acids came to be known and refined oils were popularized as alternative cooking oils. There has been conflicting and non conclusive research on the health impacts of fats. However presently a clear picture seems to emerge with better statistical tools and analytical techniques.

CLASSIFICATION OF FATTY ACIDS
Fats are broadly classified as Saturated fats and Unsaturated fats. Saturated fats are the ones which have all single bonds and are found in animal based products; butter, cheese, beef fat, coconut oil, palm oil, palm kernel oil. Unsaturated fats are further classified as MUFA (Monounsaturated Fatty Acids) and PUFA (Poly Unsaturated Fatty Acids). MUFA contain one double bond and PUFA contain more than one double bond. Olive oil, avocados and seeds are sources of MUFA. PUFA are considered essential fatty acids as human beings cannot synthesize them. Omega-3 and Omega-6 are important essential fatty acids. Fish, soyabean, cotton seed oils are some important sources of PUFA. Trans fat is generated by hydrogenation of oil and improves shelf life of fat. Trans fatty Acids (TFA) are considered risk factors for Coronary Heart Disease (CHD) (Mozaffarian et al., 2006). Saturated fats and trans fats are also called bad fats owing to health risk factors. TFAs have higher melting points, hence are solids. MUFA and PUFA have low melting points and are liquids.

Saturated fatty acids: Some of the common examples of natural SFAs are Butyric acid found in butter, Myristic acid found in cows milk and dairy products, Lauric acid found in human breast milk, cows milk and goats milk, Palmitic acid found in palm oil. Tallow, lard, red meat are rich non-vegetarian sources of saturated fats.

Unsaturated fatty acids: Monounsaturated fatty acids (MUFA): Oleic acid found in almonds (It is Omega-9 Fatty Acid).

Poly Unsaturated Fatty acids (PUFA): (i) Omega-3 fatty acids: Alpha linoleic acid (ALA) is an omega-3 fatty acid found in walnuts and Docosahexaenoic acid (DHA) found in fish, eggs are examples of omega-3 fatty acids. Flax seeds are rich source of alpha linoleic acid.

(ii) Omega-6 fatty acids: Linoleic acid (LA) is found in eggs, popcorons, vegetable oils. Gamma Linolenic acid (GLA) is found in plant based oils.

Trans fats: Elaidic Acid is trans isomer of Oleic Acid found in bovine milk (0.1%) or partially hydrogenated oils. The dairy products contain trans fats in 2-5% range. Trans fats (Hydrogenated ones) are used in cookies, pizza, biscuits, pastries etc.

NATURAL SATURATED FATS ARE RELATIVELY SAFE
For a long time people were advised to have low consumption of saturated fats (SFs) as SFs were considered...
cardiovascular risk factors. Recent studies have failed to establish a link between heart diseases and consumption of natural saturated fats. Natural saturated fats are believed to increase cholesterol levels in blood. Mainly two types of proteins carry cholesterol through blood: low density lipoproteins (LDLs) and High density Lipoproteins (HDL). LDL is considered high risk factor and HDL is considered good for heart. LDLs are further classified as small dense LDL and large LDL, based on their molecular diameters. It is the small LDL particles that have been found to be associated with Coronary artery disease (CAD) (Christopher et al., 1996). Reduced HDL levels are also correlated to CAD (Murtuza et al., 2016). In a study small, dense LDL particles were found to be significantly associated with a threefold increased risk of myocardial infarction, independent of age, sex, and relative weight (Melissa et al., 1988). A diet high in saturated fat intake can result in increase of large LDL (Dreon et al., 1998) with particular reference to Myristic acid. Myristic acid is found in mother’s milk, cow’s milk and goat’s milk. Another study at University of Bergen found improvement in ectopic fat storage, triglyceride levels, blood sugar, blood pressure, insulin when subjects were put on high intake of saturated fat (Veum et al., 2017). Diet low in fat may raise LDL levels. One study found no significant change in the LDL levels of men having large LDL, when their diet was changed to a very low fat diet (Dreon et al., 1999). Replacing saturated fat by modifying dietary fat (taking unsaturated fat or oil from plant origin) reduced the risk of cardiovascular events by 14% (Hooper et al., 2012). But merely reducing total fats had no effect on cardiovascular mortality. A meta analysis report published in 2010 found no evidence of association between saturated fat consumption and Coronary Heart Disease (CHD) or cardiovascular disease (Siri-Tarino et al., 2010). In a study on Dutch population no association was found in high SFA intake with ischemic heart disease (Praagman et al., 2016). In the worldwide dietary recommendations of replacing saturated fatty acids with LA (Omega-6) found in safflower oil was considered beneficial for cholesterol reduction. Recent studies have established no evidence of reduction in cardiovascular diseases from replacing saturated fat with LA (Christopher et al., 2013). Main sources of LA are vegetable oils.

**ISSUES AND CONCERNS**

**Trans Fats:** Conjugated Linoleic acid (CLA), a natural trans fatty acid, is found in dairy products and a report even suggests reduced risk of heart disease with diet consisting of CLA (Bonthuis et al., 2010). Intake of dairy products was not associated with mortality of increased heart risk. The study was conducted over a period of sixteen years. Natural sources of fatty acids contain small amounts of Trans fats. However studies on artificial Trans fats have confirmed their bad effects. Replacement of Saturated fatty acids with hydrogenated fats (trans fats) resulted in decreased HDL in blood and ability of arteries to dilate was also impaired (de Roos et al., 2001). Trans fats are bad in a way that they reduce HDL and increase LDL in blood increasing the risk of cardiovascular disease greatly. Food and Drug Agency of USA (FDA) has directed edible oil manufactures to completely phase out Trans fats by 2018. Trans fatty acid contents in erythrocytes have been found to be associated with an elevated risk of Cardiovascular Heart Disease (CHD) in a nested case-control study among US women (Sun et al., 2007). Another study carried out on Finish men over a period of 6 years observed a significant positive association between the intake of trans-fatty acids and the risk of coronary death (Pietinen et al., 1997). Younger women were found to be at higher risk of CHD owing to high trans fat intake (Oh et al., 2005).

**Omega 3 vs. Omega 6 fatty acids:** Omega-3 and omega-6 refers to the position of double bond from methyl end of the fatty acid. Studies show a link between diet containing omega-3 fatty acids and reduction in life threatening diseases such as heart diseases, arthritis and cancer (The nutrition source). Apart from these benefits omega-3 has been found to have anti-inflammatory properties and prevents diabetes. Omega-3, EPA (Eicosapentaenoic acid), DHA (Docosahexaenoic acid) and ALA (alpha-linolenic acid) are three important omega-3 acids. DHA is good for nervous system, good sleep and improved mood. EPA and DHA are considered good for pregnant women while humans being cannot directly use ALA but are able to convert ALA to DHA (DHA EPA Omega-3 Institute). Human body is capable of producing all fatty acid except LA (Omega-6) and ALA (Omega-3). Hence LA and ALA are essential fatty acids i.e. they must be a part of the diet. Excessive intake of omega-6 fatty acids is reported to interfere with health benefits of omega-3 fatty acids as both types compete for same enzymes (Simopoulos, 2002). Typically an omega 6 to omega 3 ratio in diet should be 1:1 based on evolutionary trends (Simopoulos, 2006). Modern diet ratio for the same is 16:1 which indicates lower omega-3 intake. A study in India has also documented low omega-3 intake across large segments of the population (Ghafourunissa, 1998). Some studies have linked this diet to breast cancer in post menopausal women and prostate cancer. Many other studies suggest an ideal ratio of 4:1 is good for health. One thing is for sure we are taking much higher amounts of omega 6 fatty acids than are actually needed. We need to either considerably reduce refined oils (that are rich in omega-6) or increase consumption of omega-3 fatty acids to maintain healthy ratio.

**Cold pressed oils vs. refined oils:** Cold pressed oils retain their nutritional values as compared to refined oils that are processed at very high temperatures to get rid of ketones and other substances. During the heating process refined oils considerably lose their nutritional value. Mustard oil, extra
expression and inflammatory diseases

A fat deficient diet may lead to deficiency of these components. Mustard oil (Kachi Ghani i.e. cold pressed oil) is rich in tocopherols which is a natural antioxidant and acts as a natural preservative. Mustard oil has 6% omega-3 (ALA) and 15% Omega-6 (LA). However a report published by FDA banned used of Mustard oil as vegetable oil (Import Alert 26-04) in US due to high erucic acid (20-40%) content which has been found to be toxic in animal studies. NIN ICMR 2010 guidelines recommend mixing mustard oil with rice bran/cottonseed/groundnut oils for reducing erucic acid content. Canola oil can also be substituted for mustard/rapeseed oil. Rice bran oil in combination with soyabean oil or mustard oil and blend of sesame oil with mustard oil provides good amount of plant sterols which are known to block cholesterol absorption in intestine Ghafourunissa (2009). Sesame oil (Til oil) is considered better for deep frying and massage as mentioned in Ayurveda. A diet high in omega-6 and low in omega-3 can lead to inflammations (Russo, 2009). Lipoxins and resolvins are metabolites of EPA and DHA that have significant anti-inflammatory properties (NIN, ICMR 2010). Soyabean Oils and canola oils have been found to contain toxic trans fats as high as 4.2% (O’Keefe, 1994). A high omega-6 to omega-3 ratio has been linked to depression and inflammatory diseases (Kiecolt-Glaser et al., 2007)

Desi ghee: A study on desi ghee on rats (for both the heated and native ghee) found a significant decrease in serum total cholesterol levels, a decrease of 20–25% in serum triglycerides, a 14–16% decrease in liver total cholesterol levels, a 14–29% decrease in liver triglyceride levels (Sharma et al., 2010). Preparation of ghee by traditional ayurvedic method contains higher amount of DHA. This method involves preparing ghee from curd (Joshi et al., 2014). DHA is an omega-3 acid and considered good for eyes, heart and brain. Another study further concluded that consumption of increased mustard oil was associated with higher CHD as compared to desi ghee (Manna et al., 2016) contrary to popular belief even among medical fraternity.

WHY WE NEED FATS IN DIET

Fats are storehouse of energy. 1 gram of fat provides 9 calories irrespective of its type. Essentials fats are important components of our brain and play important role in nerve function and transport of fat soluble vitamins; A, D, E and K. These vitamins play an important role in biological functions. A fat deficient diet may lead to deficiency of these vitamins. Fats are precursors for steroid hormones and regulate transport across cell membranes. The body stores fat around vital organs to protect them from shock. Fat layer under our skin protects as an insulating sheet and saves us from sudden temperature changes. When temperature drops very low, body metabolizes fat molecules to unlock energy and keep us warm. Dietary Fats are important precursors of Prostaglandins (Hassam et al. 1979) which regulate a number of biological functions.

IMPORTANCE OF CHOLESTEROL

Cholesterol is infamous for causing cardiovascular diseases. Cholesterol has important role in human body; as a precursor for bile acids it plays a role in digestion, building cell membranes, block of tissues and production of sex hormones like oestrogen and testosterone. About 25% of the cholesterol in body is present in Brain. New studies have emerged linking cholesterol deficiency to Alzheimer (Mulder et al., 1998). Cholesterol production occurs mainly in liver. The lipid profile is an indicator of risk of cardiovascular disease. For Indian adults a total fat intake of 20–40 gram (Sedentary to high physical activity) per day has been recommended (ICMR, 2010). Total diet cholesterol must be less than 30mg per day. SFA:MUFA:PFA are recommended at 1:1:1 levels.

Cholesterol level indicators in blood: Total Cholesterol: Less than 200mg/Dl is desirable; above 240 mg/Dl is high risk; HDL Cholesterol: Below 40mg/Dl is high risk; Tryglycerides: Below 150mg Dl is normal and above 500mg/Dl is very high risk.

VITAMIN C AND CHOLESTEROL

A meta analysis carried on 13 trials indicate that 500mg per day dose of ascorbic acid (Vitamin C) can significantly reduce LDL and Triglycerides over a period of 4 weeks (McRae 2008). Vitamin C dose of more than 400mg per day was found to be inversely associated with Cardiovascular Heart Disease in a pooled analysis of nine cohort studies (Knek et al. 2004). There is a strong evidence that replacing carbohydrates and Saturated Fatty Acids with MUFA rich diets increases HDL levels and lowers LDL Cholesterol (FAO 2008). A study found that replacing carbohydrates and saturated fats with MUFA rich diets lowers LDL levels without affecting HDL levels (Mensink and Katan 1992 and NIN ICMR 2010). Replacing SFAs with PUFA in diet lowers total cholesterol/HDL ratio (NIN, ICMR 2010). Indian Council of Medical Research recommends a LA to ALA ratio to be between 10:1 to 5:1. A diet rich in legumes, green leafy vegetables, sea foods and fish is recommended for the same. A study on blending of rice bran oil and olive oil (In ratios: 70:30 & 80:20) achieved desirable MUFA and PUFA ratios (Choudhary and Grover 2013).

Analytical results of some oils: 30 brands of oils and fats were analyzed by Pollution Monitoring Lab of Centre for Science and Environment New Delhi (Johnson and Saikia 2009). The analytical results of only those oils and fats that have values close to WHO recommended limits are mentioned for brevity.
(i) Omega 6 to Omega 3 Ratio: Mustard oil (Dhara Refined)-4.1, Desi Ghee(Milk Food)-6.7, Butter(Amul)-0.5. It is worthwhile to mention that popular brands like saffola oil have very high omega 6/3 ratio. Butter and Rice bran oil have higher omega 3 content as compared to other oils. American Heart Association (AHA) recommends that a person suffering from coronary disease should consume 1g EPA + DHA daily. However for better health and longevity an omega6/omega3 ratio should ideally be 4:1 (Caramia 2008).

(ii) PUFA/SFA: Groundnut Oil (RR Primo)-1.8, Saffola Gold-2.2, Coconut Oil (Parachute)-0.0, Olive Oil(Figaro)-0.6, Rice Bran Oil(Shalimar)-1.2, Palm Oil(Palm Gold Active) 0.2, Desi Ghee(Milk Food)-0.2, Butter(Amul)-0.1

(iii) Trans Fatty Acids: The CSE report analyzed a total of 30 products out of which 11 contained higher amount of Trans fatty acids as compared to the 2% standard of Denmark.

(iv) Omega 3: Butter and Rice Bran oil has higher amount of omega-3 as compared to other oils analyzed by the lab.

CONCLUSION

Diet high in refined oils reduces cholesterol levels. Diet high in omega-6 may lower HDL (Good Cholesterol) as well as LDL (Bad Cholesterol). However a higher omega-3 diet maintains HDL levels and lowers LDL. Modern diet is low in omega-3 fatty acids, fish may be taken as a source of omega-3 as recommended by AHA. Inflammatory diseases and hypertension incidents are on the rise due to low omega-3 and high omega-6 in the American diet (Simopoulos 2002). Moreover there is no conclusive evidence that saturated fatty acids (Desi Ghee and other natural SFAs) are bad for health (Cholesterol Levels). Natural SFAs have been reported to raise HDL levels in blood. There is conclusive evidence that trans fatty acids are bad. Some reports even distinguish between natural and processed trans fatty acids. Processed fatty acids/hydrogenated oils are used in all packaged food available in the market. There is a downward trend world over in consumption of trans fatty acids. Among the refined oils Rice Bran oil seems to be the best bet whereas Mustard oil and Desi ghee have desirable omega-3 levels(CSE report). ICMR recommends blending of mustard oil with other oils to control erucic acid level and appropriate omega6/3 ratio. Vitamin C should be made part of the daily diet and natural/homemade food should be encouraged.

REFERENCES

Bonthuis, M., Hughes, M. C., Ibibebe, T. I., Green, A. C. and van der Pols, J. C. Dairy. (2010). Consumption and patterns of mortality of Australian adults. European Journal of Clinical Nutrition, 64: 569–577. doi: 10.1038/ejcn.2010.45.

Christopher Ramsden, E., Zamora, Daisy., Leelarthaepin, Boonseng., Majchrzak-Hong, Sharon F., et al., (2013). Use of dietary linoleic acid for secondary prevention of coronary heart disease and death: evaluation of recovered data from the Sydney Diet Heart Study and updated meta-analysis BMJ; 346:e8707. doi.org/10.1136/bmj.e8707

Caramia G. (2008). The essential fatty acids omega-6 and omega-3: from their discovery to their use in therapy, Minerva Pediatrica, 60 (2): 219-33.

Choudhary, M. and Grover, K. (2013). Evaluation of fatty acid composition and oxidative stability of blended rice bran and olive oil. Asian J. Dairy & Food Res., 32 (4): 290-297

Christopher D. Gardner, PhD; Stephen P. Fortmann, MD; Ronald M. Krauss, MD. 1996. Association of Small Low-Density Lipoprotein Particles With the Incidence of Coronary Artery Disease in Men and Women. JAMA, 276 (11):875-881. doi:10.1001/jama.1996.03540110029028.

de Roos, N.M., Bots, M.L., Katan, M.B. (2001). Replacement of dietary saturated fatty acids by trans fatty acids lowers serum HDL cholesterol and impairs endothelial function in healthy men and women. Arterioscler Thromb Vasc Biol. 21(7):1233-7.

Dreon, D. M., Fernstrom, H. A., Campos, H., Blanche, P., Williams, P. T. and Krauss, R. M.1998. Change in dietary saturated fat intake is correlated with change in mass of large-density-lipoprotein particles in men. American Journal of Clinical Nutrition, 67(5):828-836.

Dreon, D. M., Fernstrom, H.A., Williams, P.T., Krauss, R.M. (1999). A very low-fat diet is not associated with improved lipoprotein profiles in men with a predominance of large, low-density lipoproteins. American Journal of Clinical Nutrition, 69(3):411-8.

FDA Import Alert 26-04 Dated 18/11/2016 Retrieved on 5 Jan 2018 in www.accessdata.fda.gov/cms_ia/importalert_89.html

FAO.(2008). WHO Fats and Fatty Acids in Human Nutrition (Report of an Expert Consultation) 2008, ISSN 0254-4725, p-15.

Ghafoorunissa.(1998). Requirements of dietary fats to meet nutritional needs and prevent the risk of atherosclerosis - An Indian perspective. Ind. J. Med. Res.;108: 191-202.

Ghafoorunissa.(2009). Impact of quality of dietary fat on serum cholesterol and coronary heart disease: Focus on plant sterols and other non-glyceride components. The National Medical Journal Of India, 22(3), 126-132.

Hassam, A.G., Willis, A.L., Denton, J.P., Stevens, P. and Crawford, M.A. (1979). The effect of essential fatty acid-deficient diet on the levels of prostaglandins and their fatty acid precursors in the rabbit brain. LIPIDS, 1(14): 78-80

Hooper, L., Summerbell, C.D., Thompson, R., Sills, D., Roberts, F.G, Moore, H.J., Davey Smith, G (2012). Reduced or modified dietary fat for preventing cardiovascular disease. Cochrane Database of Systematic Reviews, (5): 182-83. Art.No.: CD002137. DOI: 10.1002/14651858.CD002137.pub3
Johnson, S., and Saikia, N. (2009). Fatty acid profiles of Edible Oils and Fats in India, Centre for Science and Environment: 2009, CSE/PML/PR-32. (DA: 30 January 2018)

Joshi, Kalpana S., (2014). Docosahexaenoic acid content is significantly higher in ghrita prepared by traditional Ayurvedic method. Journal of Ayurveda and Integrative Medicine, 5(2): 85–88. doi: 10.4103/0975-9476.131730

Kieccl-Glaser, Janice K., PhD., Belury, Martha A. Porter, Kyle MAS., Beversdorf, David Q. MD., and Lemeshow, Stanley Glaser, Ronald. (2007). Depressive Symptoms, omega-6:omega-3 Fatty Acids, and Inflammation in Older Adults. Psychosom Med, 69(3): 217–224.

Knekt, P., Ritz, J., Pereira, M.A., O’Reilly, E.J., Augustsson, K., Fraser, G.E., Goldbourt, U., et al., (2004). Antioxidant vitamins and coronary heart disease risk: a pooled analysis of 9 cohorts. American Journal of Clinical Nutrition, 80(6):1508-1520.

Oh, K., Hu, F.B., Manson, J.E., Stampfer, M.J. and Willett, W.C. (2005). dietary fat intake and risk of coronary heart disease in women: 20 years of follow-up of the Nurses’ Health Study. American Journal of Epidemiology, 161(7), 672–679. doi.org/10.1093/aje/kwi085

Manna, S., Sharma, H.B., Vyas, S., and Kumar, J. (2016). Comparison of Mustard Oil and Ghee Consumption on the History of Coronal Heart Disease in Urban Population of India. Journal of Clinical and Diagnostic Research, 10(10):OC01–OC05. doi.org/10.7860/JCDR/2016/18929.8593

McRae, M.P. (2008). Vitamin C supplementation lowers serum low-density lipoprotein cholesterol and triglycerides: a meta-analysis of 13 randomized controlled trials. Journal of Chiropractic Medicine, 7(2): 48–58

Melissa A. Austin, Jan L. Breslow, Charles H. Hennekens, Julie E. Buring, DSc; Walter C. Willett, Ronald M. Krauss,(1988). Low-Density Lipoprotein Subclass Patterns and Risk of Myocardial Infarction. JAMA, 269(15): 1917-1921.

Mensink R.B. and Katan M.B. (1992). Effect of Dietary Fatty Acids on Serum Lipids and Lipoproteins A Meta-analysis of 27 Trials. Arteriosclerosis, Thrombosis, and Vascular Biology, 12; 911-919. doi: 10.1161/01.ATV.12.8.911

Mozaffarian, D., Katan, M.B., Ascherio, A., Stampfer, M.J., Willett, W.C. (2006). Trans fatty acids and cardiovascular disease. N. Engl. J. Med., 354(15):1601-13.

Mulder, M., Ravid, R., Swaab, D.F., de Kloet, E.R., Haasdjik, E.D., Julk, J., van der Boom, J.J., Havekes, L.M.1998. Reduced levels of cholesterol, phospholipids, and fatty acids in cerebrospinal fluid of Alzheimer disease patients are not related to apolipoprotein E4. Alzheimer Dis. Assoc. Disord., 12(3):198-203.

Murtuza Shahid, Run L Sun, Yu Liu, Jin L Bao, Can X Huang, Yu Liao, Shu X Zhou, Jing F Wang Yu L Zhang. 2016. Is high high-density lipoprotein cholesterol beneficial for premature coronary heart disease? A metaanalysis. European Journal of Preventive Cardiology, 23(7): 704-713. doi.org/10.1177/2047487315610662

NIN ICMR (2010), RDA 2010 Draft Document, Nutrient Requirements and Recommended Dietary Allowances for Indians, Report of the Expert Group of the Indian Council of Medical Research 2009, icmr.nic.in/final.rda-2010.pdf. (DA : 15 March, 2018)

O’keefe, Sean., Gaskins-Wright, Sara., Wiley, Virginia. and Chen, I-Chen. (1994). Levels Of Trans geometrical isomers of essential fatty acids in some unhydrogenated U. S. vegetable Oils. Journal Of Food Lipids, 1(3): 165–176. doi:10.1111/J.1745-4522.1994.Tb00244.X

Pietinen, P., Ascherio, A., Korhonen, P., Hartman, A.M., Willett, W.C., Albanes D. and Virtamo J.(1997). Intake of fatty acids and risk of coronary heart disease in a cohort of Finnish men. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study. Am. J. Epidemiol., 145(10):876-87.

Praagman, J., Beulens, Joline W.J., Allesma,M., Zock, P.L., Wanders, A.J., Sluijs, I., van der Schouw, Y.T. (2016). The association between dietary saturated fatty acids and ischemic heart disease depends on the type and source of fatty acid in the European Prospective Investigation into Cancer and Nutrition—Netherlands cohort. The American Journal of Clinical Nutrition.103(2),356-365. doi.org/10.3945/ajcn.115.122671.

Russo GL. (2009). Dietary n-6 and n-3 polyunsaturated fatty acids: from biochemistry to clinical implications in cardiovascular prevention. Biochem Pharmacol, 77(6):937-46.

Sharma, H., Zhang, X., Dwivedi, C., (2010) The effect of ghee (clarified butter) on serum lipid levels and microsomal lipid peroxidation. AYU, 31(2): 134–140.

Simopoulos, A.P. (2002). The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed Pharmacotherapy, 56(8):365-79.

Simopoulos, A.P. (2006). Evolutionary aspects of diet, the omega-6/omega-3 ratio and genetic variation: nutritional implications for chronic diseases. Biomedicine & Pharmacotherapy, 60(9): 502-507. doi:10.1016/j.biopha.2006.07.080.

Siri-Tarino, P.W., Sun, Q., Hu, F.B. and Krauss, R.M. (2010). Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. Am.J.Clin. Nut., 91:535-46.

Sun, Q., Ma, J., Campos, H., Hankinson, S.E., Manson, J.E., Stampfer, M.J., Rexrode, K.M., Willett, W.C. and Hu, F.B. (2007). A prospective study of trans fatty acids in erythrocytes and risk of coronary heart disease. Circulation, 115:1858–1865.

Veum, Vivian L.,Lauapa-Borge, Johnny., Eng, Øyvin.,Rostrup, Espen.,Larsen, Terje H., et al., (2017). Visceral adiposity and metabolic syndrome after very high–fat and low–fat isocaloric diets: a randomized controlled trial. The American Journal of Clinical Nutrition, 108(1), 85–99. doi.org/10.3945/ajcn.115.123463