Advances in Bioresearch
Adv. Biores., Special Issue (2) 2025: 21-26

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585. SPL2.25.2126

Advances in Bioresearch

Potential of crude and refined palm oil in inducing obesity, diabetes, CVD and cancer – A Review

[1]N. Bhavana, [1]Afsha Sultana, [1]S. Ravi Kiran, [2]N.V.L. Suvarchala Reddy, [2]M. Ganga Raju and [3]J. Achyutha Devi*

[1]Department of Botany and Food & Nutrition, R.B.V.R.R. Women's College, Narayanaguda, Hyderabad-500027, Telangana, India

[2]Department of Pharmacology, Gokaraju Rangaraju College of Pharmacy, Bachupally, Hyderabad, Telangana, India

[3]Department of Zoology, R.B.V.R.R. Women's College, Narayanaguda, Hyderabad-500027, Telangana, India

*Corresponding Author's E-mail: achyuthadevi@gmail.com

ABSTRACT

Palm oil, a common ingredient in the global food industry, is used in a vast array of other commercial products, from baked goods to cosmetics. A significant amount of research now supports that palm oil consumption may be associated with the risk of health concerns. Refined palm oil is predominantly comprised of palmitic acid, a saturated fatty acid linked to risk of insulin resistance, inflammation, and oxidative stress, leading to the development of cardio vascular diseases and cancers. This study focusses on the concise mechanism of palmitic acid inducing metastasis and excessive consumption of refined palm oil results in over accumulation of lipids which in turn contributes to development of fatty liver diseases and liver damage. The findings highlight the importance of limiting the consumption of palm oil both crude and refined forms and exploring healthier dietary options to minimize these health risks.

Keywords: Plam oil, 3-MCPDE, obesity, diabetes mellitus and metastasis

Received 09.10.2024 Revised 26.12.2024 Accepted 12.03.2025

How to cite this article:
N. Bhavana, Afsha S, S. Ravi Kiran, N.V.L. Suvarchala Reddy, M. Ganga Raju and J. Achyutha Devi. Potential of crude and refined palm oil in inducing obesity, diabetes, CVD and cancer – A Review. Adv. Biores. Special Issue [2] 2025. 21-26

INTRODUCTION

The palm oil is commonly used vegetable oil worldwide and is extracted from the fruits and seeds of the palm tree and other frequently used foods along with other consumer products from packed foods to cosmetics [1]. Wildly grows in the tropical wetlands of the world, particularly in Asia, Latin America and Africa [2]. A single palm tree contains over 2000 fruits. It is good source of edible oil and each palm fruit contains 30-35**%** of oil [3]. The crude palm oil (CPO) extracted from the fruits and seeds from outer mesocarp. And the palm kernel oil extracted from the endosperm [4]. The palm oil processing involves extraction (Oil from mesocarp, threshing (fruit removal from clusters), sterilization of bunches, digestion of fruit, pulp pressing, kernel separation, crushing of kernel, solvent extraction, crude palm oil obtained [5].

Refining of the CPO

Th process of refining is nothing but the removal impurities namely gums, fibrous materials, cell debris, non-oily solids, FFA (free fatty acids), metals, pigments, residual soap, phospholipids, VOP (volatile oxidation products) and other contaminants [6] and the process was presented in Fig-1. Major constraints of vegetable oil refining process where formation of process includes contaminants like 2-monochloropropane-1,3-diol fatty acid esters (2-MCPDE), 3-monochloropropane-1,2-diol fatty acid esters (3-MCPDE), glycidol fatty acid ester (GE) which are found to be present in palm oil in appreciable amounts [7-9]. Particularly these toxicants known to be 3-MCPDE which is proven carcinogen in animals and might alter normal functions of other major organs and also having pose to several clinical disorders like antifertility, nephrotoxic activity [10]. furthermore, classified contaminates are possibly carcinogenic

to humans by International Agency of Research on Cancer (ICAR) [11]. Thus, the maximum allowable daily intake limit for 3-MCPDE was determined at 2 µg/kg per body weight by the European Food Safety Authority (EFSA), and 4 µg/kg was set by the joint expert committee of the FAO/WHO expert committee on food additives and pollutants (JECFA) [12]. These toxicants developed during the refining process, and a number of additional variables also contribute to their creation in oil. Treating the oils at high temperatures during the bleaching, degumming, and deodorization processes is another major factor in the creation of these [8, 13].

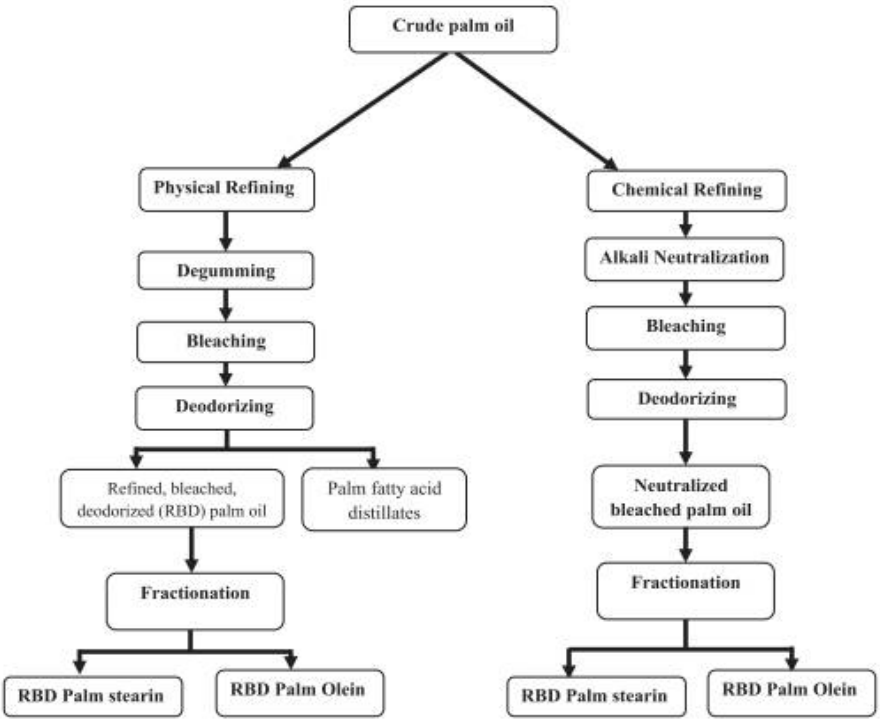

Fig.1 Crude oil refining process

The most successful processing methods currently in use to lower the 3-MCPDE of refined oil are clay washing and strong centrifugation [14]. There hasn't yet been a documented successful mitigating technique for 2-MCPDE2 decrease [8].

Palm Oil and Palmitic Acid – Biological and Nutritional properties

The crude palm oil CPO also known as red palm oil RPO, is extracted through wet or dry methods. It contains a variety of beneficial and healthful compounds, including vitamin E, carotenoids, phytosterols, and triacylglycerols (TAG). However, it also contains impurities, including gums, phospholipids, free fatty acids (FFAs), and lipid oxidation products, which can be eliminated through refining procedures [16]. The effects of palm oil both crude and refine forms on human health was depicted in Fig-2.

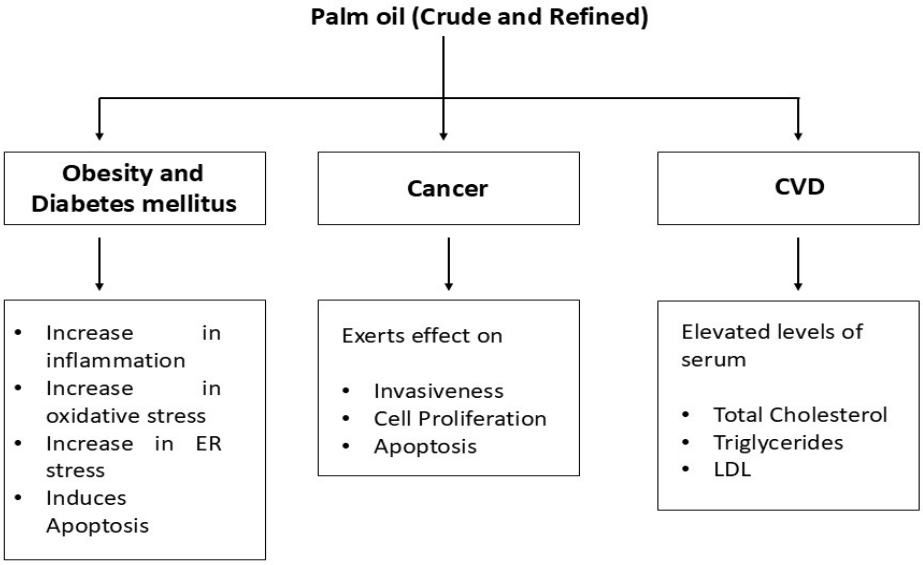

Fig-2: Effects of Palm oil on human health

The highest naturally occurring source of carotenoids (500–700 ppm), tocopherols, and tocotrienols (600–1200 ppm) contributes to the stability and nutritional qualities [15]. Additionally, CPO has antioxidant qualities that are used to prevent cancer, reduce CVD, and combat reactive oxygen species (ROS) [16]. Tocotrienols have also been described as naturally occurring inhibitors of the synthesis of cholesterol [17]. Crude Palm Oil (CPO) undergoes refining to remove impurities and achieve desired colour and flavour for food manufacturing. This involves chemical or physical refining methods, followed by bleaching and deodorizing steps to produce high-quality oil. While physical refining is the preferred method due to environmental and cost benefits, it has drawbacks. These include losses of beneficial compounds like tocopherols and tocotrienols, oxidative damage, and reduced storage stability, requiring careful degumming and processing to maintain quality [18]. Low-quality oils are utilized in non-edible industries like soap and cosmetics, while so-called high-quality PO is made up of less than 0.5% FFAs and more than 95% neutral triacylglycerols, or triglycerides, which are used in the food business [19]. PO and PKO exhibit distinct physical and chemical characteristics, primarily contingent on their intended uses. The PO includes 50% SFAs, primarily palmitic acid (PA, 44%) and smaller quantities of stearic acid (5%), 40% monounsaturated fatty acids (MUFAs), primarily oleic acid, and 10% polyunsaturated fatty acids (PUFAs), primarily linoleic acids, PKO contains 85% SFAs, primarily lauric and myristic acids[17]. The primary SFA found naturally in vegetable and animal oils, as well as the primary ingredient in human milk fat, is PA [20]. Palm olein, with its high oleic acid content, has been proposed as a healthy alternative to olive oil in healthy normo-cholesterolemic human diet [16] However, debates persist about PO's potential health effects, primarily due to its elevated levels of palmitic acid (PA) content [21-23]. PO, like other vegetable oils, is cholesterol-free and composed of triglycerides (TAGs) with oleic acid mainly at the SN^2 position and PA at SN^1 and SN^3 positions, differing from animal fats where PA often occupies the SN^2 position [24].

Role of palm oil and palmitic acid in metabolic disorders

Obesity a metabolic disorder where his is characterized by the excess of the adipose tissue (WAT) causing due to the excess energy stored and deposited in the adipose as TAG, responsible for causing adipose hypertrophy and hyperplasia [25]. Over 2 billion adults worldwide (39% of adults aged 18 years and older) live with overweight, and 770 million (13%) live with obesity. Children around 40 million under 5 years of age were found to be overweight or obese in 2020 [26]. Nonetheless, disorders associated with obesity as per the data from the International Diabetes Federation (IDF), 1 in 10 persons had diabetes in 2021, with type 2 diabetes accounting for 90% of occurrences [27]. WAT generates adipokines linked to metabolic disorders associated with obesity and mechanisms that cause chronic inflammation [28]. Increased SFA depots from the adipose tissues of obese mice trigger inflammatory signaling mediated by Toll-like receptor 4 (TLR4) [29-31]. Saturated fatty acids (SFAs) activate pro-inflammatory pathways, both TLR-dependent and TLR-independent, through ROS (Reactive Oxygen Species), which drive the maturation of interleukin-1β (IL-1β), leading to insulin resistance (IR) via suppression of insulin signalling in target cells. Additionally, high-fat diets (HFDs) have been linked to metabolic endotoxemia,

wherein lipopolysaccharides (LPS) from Gram-negative gut microbiota activate inflammation via the TLR4 pathway, further elevating pro-inflammatory cytokines like IL-6 and contributing to obesity-related IR [32]. A palm oil (PO)-rich diet is connected with increase in weight gain, hepatic lipid accumulation, and reduced gut microbial diversity, promoting obesity. Palmitic acid (PA), a primary constituent of PO, enhances IL-6 secretion and cooperates with LPS to exacerbate inflammatory responses [33]. In obesity and diabetes mellitus, elevated pro-inflammatory cytokines (TNF-α, IL-6, leptin) impair insulin action and contribute to β-cell dysfunction. Increased ROS in diabetes leads to oxidative stress and endothelial dysfunction, heightening the risk of cardiovascular diseases (CVD). The possible role of PO in diabetes is controversial at present, with some studies suggesting impaired glucose tolerance and insulin sensitivity, while others show minimal effects. PA impairs insulin signalling through mechanisms such as ER stress, inhibition of insulin receptor phosphorylation, and ubiquitination of key insulin-signalling molecules, promoting IR and β-cell apoptosis [34]

Palm oil in CVD

Biomedical Research indicates that palm oil, which is high in saturated fat and low in polyunsaturated fat, promotes heart diseases. Though less harmful than partially hydrogenated vegetable oil, it is far more conductive to heart diseases than such heart - protective liquid oils such as: olive oil, soya and canola oil. National Heart, Lung and Blood Institute (NHLBI), WHO and other health authorities have urged to reduce the consumption of palm oil to reduce the risk of CVD among the populations. According to WHO Consuming refined palm oil can lead to an increased risk of cardiovascular disease. Excessive consumption can lead to an imbalance of fatty acids in the body. The study emphasizes on the complexity of the issue and the need for nuanced understanding that PA content in PO and its potential impact on CVD risk. Comparison of PO with other oils (e.g., soybean, olive, sunflower, canola) show no considerable differences in lipid profiles. The importance of fatty acid chain length, saturation, and stereospecific positioning in TAG structures. The atherogenicity of specific TAGs and the role of PA at the SN^2 position. The potential benefits of PO's typical TAG structure, with PA at SN^1 and SN^3 positions, reducing atherogenicity. Excessive Consumption may pose adverse effects on lipid profiles and hepatic health revealing: Dyslipidemia, Hepatic lipid accumulation, miRNA dysregulation, potentially leading to metabolic disturbances. These findings underscore the importance of adhering to recommended dietary guidelines for palm oil consumption to prevent adverse effects on cardiovascular and hepatic health.

Palm oil and metastasis

Metastasis is characterized by the intake of fatty acids and altered metabolism; however, there is a dearth of information regarding the biology underpinning these processes and whether or not all dietary fatty acids are prometastatic. Metastasis is characterized by the intake of fatty acids and altered metabolism; however, there is a dearth of information regarding the biology underpinning these processes and whether or not all dietary fatty acids are prometastatic. Research studies demonstrate that the oral carcinomas and melanoma in mice are more likely to metastasize when dietary palmitic acid (PA) is present, but not oleic acid or linoleic acid. Even after being serially transplanted, tumors from mice fed a short-term diet high in palm oil (PA) or tumor cells that were momentarily exposed to PA in vitro remained highly metastatic. A person's diet plays a significant role in the disease progression including cancer, as it alters the nutrient levels and composition within the tumor microenvironment (TME). This, in turn, can impact cancer cell growth, metabolism, and response to treatment. Further palmitic acid-enriched diet can epigenetically reprogram cancer cells, adopting a neural-like identity that fosters tumor nerve infiltration and metastatic spread, highlighting the critical role of diet in shaping cancer behavior [35]. The study also investigated the role of fatty acids in metastasis formation and found that pretreating human oral squamous cell carcinoma cells with palmitic acid (PA), but not oleic acid (OA) or linoleic acid (LA), significantly increased metastasis in mice without affecting primary tumor growth. Research indicates that there may be a connection between postmenopausal women's fatty acid intake and breast cancer risk. Positive correlations have been observed between the following: total MUFA intake and breast cancer incidence; intake of palmitic acid (PA) and stearic acid and breast cancer incidence (89% higher risk) [36]. One of the most important enzymes in the metabolism of fatty acids, fatty acid synthase (FAS), is overexpressed in a number of human malignancies, including colorectal, breast, and non-small-cell lung cancer, which is the main cause of cancer death. This supports the idea that certain fatty acids, such as palmitic acid (PA), are important in controlling the growth and progression of tumors by suggesting FAS as a possible prognostic tumor marker and therapeutic target [37-39]. Evidence linking a proregenerative state of tumor-activated Schwann cells to a dietary chemical that produces stable transcriptional and chromatin alterations that result in a long-term encouragement of metastasis.

CONCLUSION

The study signifies the contribution of refined palm oil and palmitic acid to metabolic disorders, including obesity and type 2 diabetes, by promoting chronic inflammation, insulin resistance, and pancreatic beta-cell dysfunction, ultimately increasing the risk of cardiovascular diseases. As extensively consumed vegetable oil globally, palm oil's presence in various food products has raised questions about its potential impact on glucose tolerance, fatty liver and cancer. Moderate consumption of high-quality palm oil, particularly palm stearin, can be part of a healthy diet. Regulatory bodies should ensure proper testing and labelling, and further research should focus on minimizing process-induced toxicants. A balanced perspective and informed choices can help consumers navigate the complexities of palm oil's health effects.

Further research is needed to elucidate the mechanisms and potential therapeutic targets for mitigating the adverse effects for making a healthy and sustainable living.

ACKNOWLEDGEMENTS

All the authors express their gratitude to the Management of R.B.V.R.R. Women's College, Narayanaguda, Hyderabad, India and Gokaraju Rangaraju College of Pharmacy, Bachupally, Hyderabad, India for their constant support and encouragement throughout the tenure of the research work.

Competing Interests

The authors declare that there are no competing interests

REFERENCES

1. Ismail, M., Alsalahi, A., Imam, M.U., Ooi, J., Khaza'ai, H., Aljaberi, M.A., Shamsudin, M.N. & Idrus, Z. (2020). Safety and Neuroprotective Efficacy of Palm Oil and Tocotrienol-Rich Fraction from Palm Oil: A Systematic Review. Nutrients. 12(2):521-553
2. Absalome, M.A., Massara, C.C., Alexandre, A.A., Gervais, K., Chantal, G.G., Ferdinand, D., Rhedoor, A.J., Coulibaly, I., George, T.G., Brigitte, T., Marion, M. & Jean-Paul, C. (2020). Biochemical properties, nutritional values, health benefits and sustainability of palm oil. Biochimie. 178:81-95
3. Gesteiro, E., Guijarro, L., Sánchez-Muniz, F.J., Vidal-Carou, M.D.C., Troncoso, A., Venanci, L., Jimeno, V., Quilez, J., Anadón, A. & González-Gross, M. (2019). Palm Oil on the Edge. Nutrients. 11(9):2008.
4. Sheil, Douglas & Casson, Anne & Meijaard, Erik & Van Noordwijk, Meine & Gaskell, Joanne & Sunderland-Groves, Jacqueline & Wertz, Karah & Kanninen, Markku. (2009). The Impacts and Opportunities of Oil Palm in Southeast Asia: What do We Know and What do We Need to Know. ISBN 978-979-1412-74-2
5. Urugo, M.M., Teka, T.A., Teshome, P.G. & Tringo, T.T. (2021). Palm oil processing and controversies over its health effect: overview of positive and negative consequences. J. Oelo. Sci. 70(12):1693-1706
6. Aparicio, R. & Harwood, J. (2013). Handbook of olive oil: Analysis and properties. Springer.
7. Oey, S.B., Van der Fels-Klerx, H.J., Fogliano, V. & Van Leeuwen, S.P.J. (2020). Effective physical refining for the mitigation of processing contaminants in palm oil at pilot scale. Food Res. Int. 138:109748
8. EFSA Panel on Contaminants in the Food Chain (CONTAM). (2016). Risks for human health related to the presence of 3-and 2 monochloropropanediol（MCPD) and their fatty acid esters, and glycidyl fatty acid esters in food. European Food Safety Authority Journal 14(5): 4426-4585
9. Cheng, W., Liu, G., Wang, L. & Liu, Z. (2017). Glycidyl fatty acid esters in refined edible oils: A review on formation, occurrence, analysis, and elimination methods. Compr. Rev. Food Sci. Food Saf. 16(2): 263-281
10. Gao, B., Li, Y., Huang, G. & Yu, L. (2019). Fatty acid esters of 3-monochloropropanediol: A review. Annu. Rev. Food Sci. Technol. 10: 259-284
11. Arisseto, A.P., Silva, W.C., Tivanello, R.G., Sampaio, K.A. & Vicente, E. (2018). Recent advances in toxicity and analytical methods of monochloropropanediols and glycidyl fatty acid esters in foods. Curr. Opin. Food Sci. 24: 36-42
12. Cui, X., Zhang, L., Zhou, P., Liu, Z., Fan, S. (2021). Dietary exposure of general Chinese population to fatty acid esters of 3-monochloropropane-1,2-diol（3- MCPD from edible oils and oil-containing foods. Food Addit. Contam. Part A Chem. Anal. Control. Expo. Risk. Assess. 38(1): 60-69
13. Jiang, L., Jing, Z., Yibaina, W., Yan, S., Lili, X. (2021). Dietary exposure to fatty acid esters of monochloropropanediols and glycidol of 2- to 3-year-old children attending nursery schools from two areas in China using the duplicate-diet collection method. Food Addit. Contam. Part A Chem. Anal. Control. Expo. Risk. Assess. 38(1): 70-80
14. Theurillat, X., Nicolas, M., Redeuil, K. & Nagy, K. (2020). Synergistic effects during physical refining of palm oil to mitigate the formation of monochloropropanediols. Eur. J. Lipid Sci. Technol. 122(10): 2000071: 1-12
15. Mba, O.I., Dumont, M.J. & Ngadi, M. (2015). Palm oil: Processing, characterization and utilization in the food industry. A review. Food Biosci. 10(4): 26-41
16. Sambanthamurthi, R., Sundram, K. & Tan Y.A. (2000). Chemistry and biochemistry of Palm Oil. Prog. Lip Res. 39(6):507–558

17. Edem, D.O. (2002). Palm Oil: Biochemical, physiological, nutritional, hematological, and toxicological aspects: A review. Plant. Foods Hum. Nutr. 57(3-4): 319-341
18. Dunford N.T. (2012). Food and Industrial Bioproducts and Bioprocessing. John Wiley and Sons Inc., USA
19. Gunstone F.D. (2011). Vegetable Oils in Food Technology: Composition, Properties and Uses. 2nd ed. Blackwell Publishing Ltd., West Essex, UK
20. Jensen, R.G. (1996). The lipids in human milk. Prog. Lipid Res. 35(1): 53-92
21. Odia, O.J., Ofori S. & Maduka O. (2015). Palm Oil and the heart: A review. World J. Cardiol. 7(3): 144-149
22. Fattore, E. & Fanelli, R. (2013). Palm oil and palmitic acid: A review on cardiovascular effects and carcinogenicity. Int. J. Food Sci. Nutr. 64(5): 648-659
23. Fattore, E., Bosetti, C., Brighenti, F., Agostoni, C. & Fattore G. (2014). Palm oil and blood lipid-related markers of cardiovascular disease: A systematic review and meta-analysis of dietary intervention trials. Am. J. Clin. Nutr. 99(6): 1331-1350
24. May, C.Y. (2014). Nesaretnam K. Research advancements in palm oil nutrition. Eur. J. Lipid Sci. Technol. 116(10): 1301-1315
25. Dixon, J.B. (2010). The effect of obesity on health outcomes. Mol. Cell. Endocrinol. 316(2): 104-108
26. World Health Organization. (2022). Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed on 12th May 2024
27. IDF Diabetes Atlas (2021). https://diabetesatlas.org/atlas/tenth-edition/. Accessed on 24th April 224
28. Exley, M.A., Hand, L., O'Shea, D. & Lynch, L. (2014). Interplay between the immune system and adipose tissue in obesity. J. Endocrinol. 223(2): R41-48.
29. Ajuwon, K.M. & Spurlock, M.E. (2005). Palmitate activates the NF-kappaB transcription factor and induces IL-6 and TNFalpha expression in 3T3-L1 adipocytes. J. Nutr. 135(8):1841-1846.
30. Bradley, R.L., Fisher, F.F. & Maratos-Flier, E. (2008). Dietary fatty acids differentially regulate production of TNF-alpha and IL-10 by murine 3T3-L1 adipocytes. Obesity (Silver Spring). 16(5):938-944.
31. Wang, X., Cheng, M., Zhao, M., Ge, A., Guo, F., Zhang, M., Yang, Y., Liu, L. & Yang, N. (2013). Differential effects of high-fat-diet rich in lard oil or soybean oil on osteopontin expression and inflammation of adipose tissue in diet-induced obese rats. Eur. J. Nutr. 52(3):1181-1189
32. Jager, J., Grémeaux, T., Cormont, M., Le Marchand-Brustel, Y. & Tanti, J.F. (2007). Interleukin-1beta-induced insulin resistance in adipocytes through down-regulation of insulin receptor substrate-1 expression. Endocrinol. 148(1):241-51.
33. de Wit, N., Derrien, M., Bosch-Vermeulen, H., Oosterink, E., Keshtkar, S., Duval, C., de Vogel-van den Bosch, J., Kleerebezem, M., Müller, M. & van der Meer, R. (2012). Saturated fat stimulates obesity and hepatic steatosis and affects gut microbiota composition by an enhanced overflow of dietary fat to the distal intestine. Am. J. Physiol. Gastrointest. Liver Physiol. 303(5):G589-99
34. Magri, T.P., Fernandes, F.S., Souza, A.S., Langhi, L.G., Barboza, T., Misan, V., Mucci, D.B., Santos, R.M., Nunes, T.F., Souza, S.A., de Mello Coelho, V. & Tavares do Carmo, Md. (2015). Interesterified fat or palm oil as substitutes for partially hydrogenated fat in maternal diet can predispose obesity in adult male offspring. Clin. Nutr. 34(5):904-910
35. Pascual, G., Domı´nguez, D., Elosu´ a-Bayes, M., Beckedorff, F., Laudanna, C., Bigas, C., Douillet, D., Greco, C., Symeonidi, A. & Herna´ ndez, I., (2021). Dietary palmitic acid promotes a prometastatic memory via Schwann cells. Nature 599(7885),485–490.
36. Sczaniecka, A.K., Brasky, T.M., Lampe, J.W., Patterson, R.E. & White, E. (2012). Dietary intake of specific fatty acids and breast cancer risk among postmenopausal women in the VITAL cohort. Nutr. Cancer. 64(8): 1131–1142.
37. Kuhajda, F.P., Pizer E.S., Li, J.N., Mani, N.S., Frehywot, G.L. & Townsend, C.A. (2000). Synthesis and antitumor activity of an inhibitor of fatty acid synthase. Proc. Natl. Acad. Sci. USA. 97(7): 3450–3454.
38. Nigro, E., Imperlini, E., Scudiero, O., Monaco, M.L., Polito, R., Mazzarella, G., Orrù, S. & Bianco, A. (2015). Daniele A. Differentially expressed and activated proteins associated with non-small cell lung cancer tissues. Respir. Res. 16:74-83
39. Pandey, P.R., Liu, W., Xing, F., Fukuda, K. & Watabe, K. (2012). Anti-cancer drugs targeting fatty acid synthase (FAS) Recent Pat. Anticancer Drug Discov. 7(2):185–197.