

COMPREHENSIVE REVIEW OF OMEGA FATTY ACIDS AND THEIR ROLE IN HUMAN HEALTH CARE.

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Abstract

Fatty acids (FAs) are the compounds of animal and vegetable fats and oils, also found in cell membranes as a component of phospholipids. They represent a class of long hydrocarbon chain molecules (C4 to C28 atoms) with a terminal carboxylate group. The common dietary source of FAs is dietary fats, which are degraded to the final digestive products monoglycerides and free FA. In the body, most FAs are stored as triacylglycerols (TGs), the uncharged esters of glycerol, and three FAs. Unsaturated fatty acids such as Omega-3,-6,-7, 9 impose several biological effects and health benefits. These omega FAs are generally present in several vegetable oils, Fish and other seafood, Nuts and seeds, and Fortified foods. The role of omega fatty acids in human healthcare is in infection, inflammation, cancer, cardiovascular diseases, diabetes, obesity, osteoporosis, hypertension, neuropsychiatric disorders, and eye diseases. and bone fractures are major chronic diseases.

Keywords: - Omega fatty acids (-3, -6, -7, -9), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), linoleic acid (LA), alpha-linolenic acid (ALA), Palmitoleic acid, oleic acid.

INTRODUCTION

Fatty acids (FAs) are the compounds of animal and vegetable fats and oils, also found in cell membranes as a component of phospholipids. The unsaturated omega fatty acids have hydrocarbon chains with a carboxyl group at one end and a methyl group at the other end. The biological reactivity of fatty acids is defined by the length of the carbon chain by both presences of the number and position of any double bonds. unsaturated fatty acids contain at least one double bond, when two or more double bonds are present, unsaturated fatty acids are referred to as PUFA. There are two families of PUFA, and they are classified as omega-3 (n-3) and omega-6 (n-6) based on the location of the last double bond relative to the terminal methyl end of the molecule, whereas saturated fatty acids do not contain double bonds within the acyl chain¹. while one double bond is present in the fatty acid chain referred to as monounsaturated fatty acids [MUFA]. There also have two families which are classified as omega-7 and -9 fatty acids (FAs). Unsaturated fatty acids such as Omega-3,-6,-7,-9 fatty acids impose several biological effects and health benefits. These omega FAs are generally present in several vegetable oils, Fish and other seafood, Nuts and seeds, and Fortified foods. Omega-3 and omega-6 FAs are well characterized regarding their benefits to human health. However, omega-7 and -9 FAs have recently received wide attention due to emerging studies and discoveries regarding their biological benefits and or risks. Essential fatty acids such as omega -3 and -6 polyunsaturated fatty acids n-3 Omega are widely accepted as a part of modern nutrition because of their beneficial effects on metabolism. Most significantly, the reported protective effect of the n-3 omega fatty acids on cardiovascular inflammatory diseases and cancer has led people to consider these fatty acids more beneficial than other dietary supplements and may also benefit patients with dyslipidemia, atherosclerosis, hypertension, diabetes mellitus, metabolic syndrome, obesity, inflammatory diseases, neurological/ neuropsychiatric disorders, and eye diseases. Omega-6 fatty acids are primarily helpful to regulate normal brain functioning and the body's growth and organ development. In addition to these responsibilities, additional benefits of omega 6 fatty acids to the body by helping to stimulate hair and skin growth, regulate metabolism, and maintain healthy bones and a healthy reproductive system. Non-essential fatty acids such as omega -7 and -9 omega fatty acids, omega 7 fatty acid can be found in foods like macadamia nuts and a fruit called sea buckthorn, but it is also produced naturally within the body. Omega-7 works against that palmitic acid by providing incredible benefits it reduces inflammation and insulin resistance whereas palmitic

acid increases it and is useful for gastrointestinal health, a healthy heart, and a youthful appearance. The last of the omega is omega-9. This fatty acid benefits the body by reducing inflammation, much like omega-3, helping to improve joint health and healing, as well as preventing a variety of diseases.

OMEGA-3 FATTY ACIDS

Omega-3 (ω -3) fatty acids are polyunsaturated fatty acids (PUFAs) and essential components for the growth of higher eukaryotes^{2,3}. Nutritionally, eicosapentaenoic acid (EPA, 20:5) and docosahexaenoic acid (DHA, 22:6) are the most significant fatty acids in the group of bioactive compounds. These long-chain omega-3 fatty acids provide significant health benefits to the human population, particularly in reducing cardiac diseases such as arrhythmia, stroke, and high blood pressure. They have observed additional beneficial effects on rheumatoid arthritis, depression, and asthma⁴. Currently, the principal source of EPA and DHA for human consumption is marine fatty fish such as salmon, mullet, and mackerel. Fish oil is not suitable for vegetarians and the odor makes it unattractive. There is a variety of alternative EPA and DHA sources such as bacteria, fungi, plants, and microalgae that are currently being explored for commercial production. Fungi require an organic carbon source and typically long growth periods, plants need arable land, have longer growth times, and have no enzymatic activity for producing long-chain PUFAs EPA and DHA unless genetically modified. Microalgae are the initial EPA and DHA producers in the marine food chain and can naturally grow fast under a variety of autotrophic, mixotrophic, and heterotrophic culture conditions with high long chain ω -3 fatty acid production potential⁵

ROLE OF OMEGA-3 FATTY ACIDS IN HUMAN HEALTH CARE

1] Omega-3 fatty acids and viral infection

Omega-3 FAs may be an effective antibacterial agent with a low risk of drug resistance. The metabolites of both omega-3 and omega-6 play a crucial role in the synthesis of different mediators such as prostaglandins, leukotrienes, thromboxanes, protections, and resolving. The study shows that fish oil enhances antiviral response by inducing interferon (IFN) which inhibits viral replication. The anti-inflammatory effect of omega-3 FAs is greater in DHA compared to that of EPA, and their secretion of cytokines IL-10 is further increased by omega-3. CD8 T cells are responsible for fighting against viruses by inducing the production of different cytokines in the body, such as Tumour Necrosis Factor-alpha (TNF-alpha) and granzyme B. However, the surge of cytokines by CD8 T cells to defend against influenza viruses imposes unintended lung damage and further deteriorates the clinical outcome. Omega-3 FAs weaken the antiviral response by CD8 T cells and could potentially be used to modulate cytokine responses as an antiviral response⁶.

2] Neurological/neuropsychiatric disease

Many neurological and neuropsychiatric disorders do not have curative treatments. The potential benefits of n-3 FAs in some of these disorders have been investigated recently. Docosahexaenoic acid (DHA), an n-3 FA found abundantly in the normal human brain, is decreased in the brain and plasma of patients with dementia. Subjects with high plasma DHA concentrations (those with a mean fish intake of 3.0 servings a week) had a 47% reduction in the risk of developing all-cause dementia in a cohort from the Framingham Heart Study. Improved motor function in patients with Huntington's disease has been reported with n-3 FA treatment. An association between depression and low dietary intake of n-3 FAs has been observed in several studies. A recent meta-analysis showed that treatment with n-3 FAs can improve patients with clearly defined depression and bipolar disorders. Prevention of excessive aggression at times of high mental stress in young adults and improvement in behavior, reading, and spelling performance of children with developmental coordination disorder are the other reported beneficial effects of n-3 FAs that may evoke enthusiasm for future research⁷.

3] Hypertension

The blood pressure-lowering effect of n-3 FAs is well established in both hypertensive and normotensive subjects. n-3 FAs reduce both systolic and diastolic blood pressure. People consuming n-3 FAs regularly are less likely to develop hypertension⁷.

4] Omega -3 Fatty acids and Pregnancy Outcomes

Maternal intake of n-3 FAs has been shown to reduce the chance of premature birth. Maternal supplementation during pregnancy and lactation has also been shown to improve the child's mental development⁷. n-3 FAs are important in the development of the nervous system, and a poor supply of these essential nutrients during fetal and immediate neonatal life may adversely affect intelligence. The World Association of Perinatal Medicine Dietary Guidelines Working Group recommends that the fetus and neonate should receive n-3 FAs in amounts

sufficient to support optimal visual and cognitive development. Pregnant and lactating women should aim to achieve an average daily intake of at least 200 mg DHA. To achieve this goal, at least consume one to two portions of sea fish a week, the women of childbearing. Intake of the DHA precursor, α -linolenic acid, was found to be far less effective in DHA deposition in the fetal brain than performed DHA from oily fish⁸.

5] Rheumatological conditions

n-3 FAs are effective in the management of pain associated with several inflammatory joint disorders. Dietary supplements of fish oil can be used as a non-steroidal anti-inflammatory drug (NSAID) sparing agent in patients with rheumatoid arthritis. A recent meta-analysis of randomized controlled trials assessing the pain-relieving effects of omega-3 FAs in patients' consumption at 3–4 months with rheumatoid arthritis or joint pain secondary to inflammatory bowel disease and dysmenorrhoea showed significant improvements in patient-reported joint pain intensity, duration of morning stiffness, number of painful and tender joints, and NSAID⁹.

6] Cardiovascular disorders

The cardiovascular benefits of diets rich in n-3 FAs were first observed in studies on Greenland Eskimos¹⁰. Many subsequent studies have proved beyond doubt the concept of cardiovascular protection offered by n-3 FAs by reducing the risk of arrhythmias, decreasing platelet aggregation¹¹, lowering plasma triglycerides, increasing high-density lipoprotein (HDL)-cholesterol, increasing the low-density lipoprotein (LDL) particle size, decreasing blood pressure, reducing the tendency for coronary restenosis and improving vasodilatation. The most compelling evidence for the cardiovascular benefit provided by n-3 FAs comes from an analysis of pooled data from three large controlled trials with 32000 participants that showed a 19–45% reduction in cardiovascular events¹².

OMEGA 6 FATTY ACIDS

Omega-6 fatty acids are essential fatty acids and are necessary for human health, but the body is unable to produce them. You will get them through food. Both the omega-3 and omega-6 fatty acids play an important role in normal growth and development and brain functions. Also, omega-6 fatty acids help to maintain bone health, regulate metabolism, stimulate skin and hair growth, and also help to maintain the reproductive system. Omega-3 and omega-6 fatty acids are balanced by a healthy diet. Omega-6 fatty acids tend to promote inflammation and Omega-3 fatty acids help reduce inflammation. Some studies suggested that elevated intakes of omega-6 fatty acids may play a role in complex regional pain syndrome. There are different types of omega-6 fatty acids, and not all promote inflammation. Most omega-6 fatty acids in the diet come from vegetable oils, such as linoleic acid (LA), not to be confused with alpha-linolenic acid (ALA), which is an omega-3 fatty acid. Linoleic acid is converted to gamma-linolenic acid (GLA) in the body. It can then break down further into arachidonic acid (AA). GLA is found in several plant-based oils, including borage oil, black currant seed oil, and evening primrose oil (EPO). GLA may reduce inflammation. A sufficient intake of specific minerals (such as magnesium, zinc, and vitamins C, B3, and B6) aids in the conversion of GLA to DGLA.

ROLE OF OMEGA 6 FATTY ACIDS IN HUMAN HEALTHCARE

1] Omega-6 fatty acids in idiopathic male infertility

A decrease in male fertility has occurred over the years. Sperm density had fallen by 40% over the past 50 years. Infertility caused by idiopathic oligoasthenoteratozoospermia (OAT) syndrome without any female factor represents one of the biggest patients group in the daily practice of urologists. The significant effect of dietary fatty acids on male fertility has been well documented both in animal and human studies¹³.

2] Type 2 Diabetes: -

Omega 6 fatty acids are beneficial for improving lipid profiles in healthy individuals and among type 2 diabetic patients. Diabetes increases the risk of cardiovascular morbidity and mortality through the various abnormalities in glucose, lipid, and lipoproteins metabolism, increases platelet aggregation, and endothelial dysfunction, and increases the risk of cardiac arrhythmia. The diet included omega fatty acids that can play prevention of type 2 diabetes Mellitus¹⁴.

3] Wound healing omega 6 fatty acids:-

Wound healing is an evolutionarily conserved process essential for species' survival. An investigation of factors that improve wound healing is of crucial interest. Experimental and clinical studies indicate that LA improves

wound healing due to its biphasic effects on the inflammatory phase of tissue repair. CLA seems to have antioxidant and anti-inflammatory effects on the later inflammatory phase of tissue repair, favoring the beginning of the proliferative phase¹⁵.

PATHWAY OF CONVERSION OF ESSENTIAL FATTY ACIDS TO THEIR MORE UNSATURATED AND LONGER CHAIN DERIVATIVES.

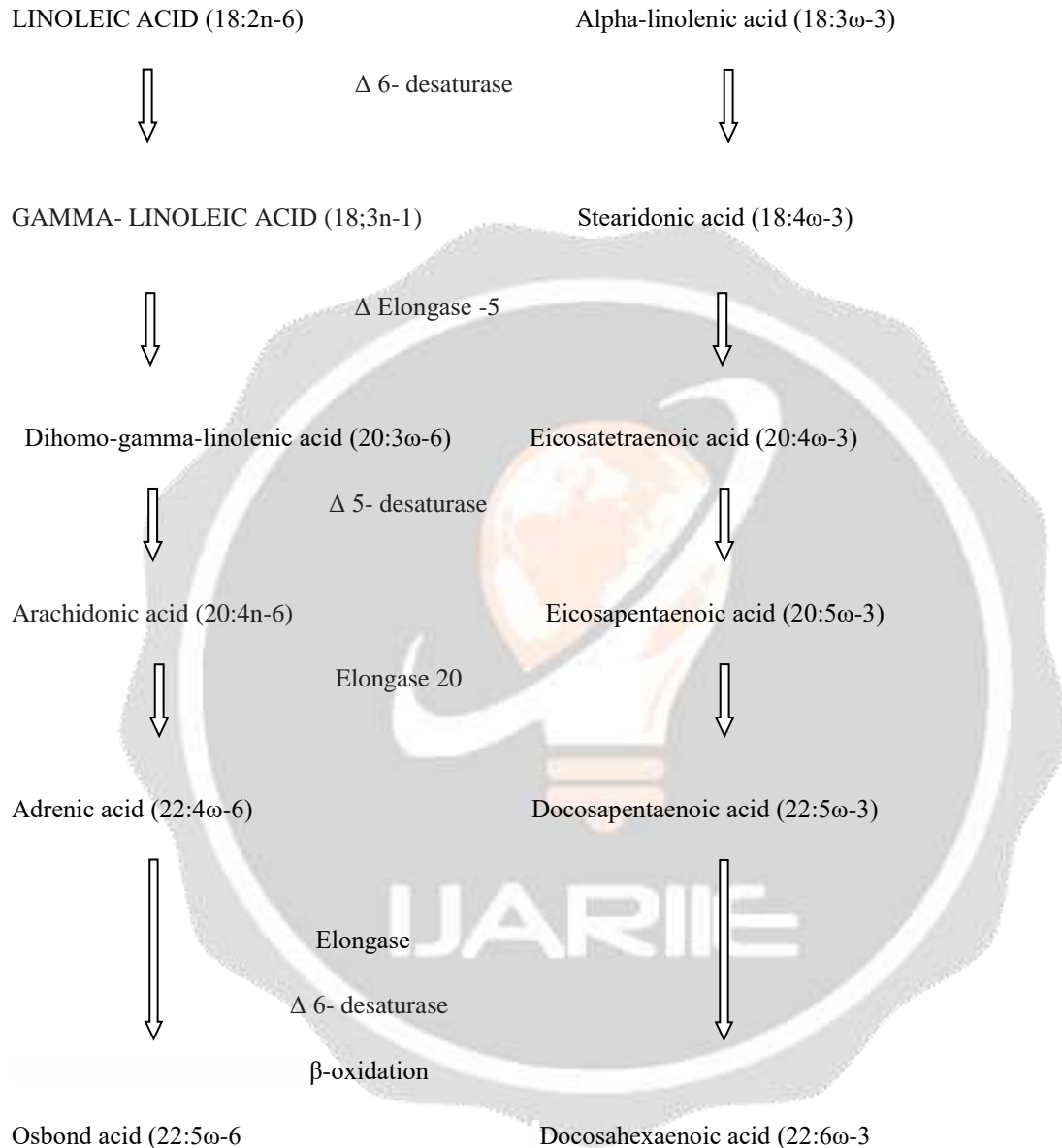


Fig: 1 (Pathway of conversion of essential fatty acids to their more unsaturated and longer chain derivatives).

Source of omega-3 and 6 fatty acids

Marine sources: - fish, mussels, oysters, shrimp but primarily cold-water fish

Plant source: - Chia seeds, brussels sprouts, algal oil, hemp seed, walnuts, flaxseeds, perilla oil

Vegetable oils: - soybean and canola oil.

OMEGA-7 FATTY ACIDS

Hundreds of clinical studies have demonstrated the benefits of omega fatty acids, especially for cardiovascular and cerebral health, over the past few decades¹⁶. In recent years, a scientist has focused their attention on a “family member” that nobody is talking about, omega 7, which has been shown to improve skin and mucous membrane health as well as insulin sensitivity and prevent cardiovascular disease. The monosaturated fatty acid omega-7 (or palmitoleic acid) is a part of the natural structure of the skin and mucous membrane of the body and its intake offers several benefits although it is considered essential. Omega 7 fatty acids diet is not always easy, since it is found only in certain foods and in small quantities. Thus, we find it in fish such as anchovy, and salmon, in Macadamia nuts, and in avocado, as well as in olive oil and other vegetable and marine oils (such as cod liver oil). But undoubtedly one of the largest known natural sources is the fruit of the sea buckthorn (*Hippophae rhamnoides*). From the berries of this plant, you get an oil that is characterized by a unique content of fatty acids compared to other vegetable oils. This oil contains an extraordinary richness of omega 7. In addition, it is also a source of numerous vitamins and bioactive components such as flavonoids and carotenes, so it is a promising natural remedy for reducing cardiovascular risk and other health problems such as inflammatory diseases or diabetes. We are facing one of the oldest plants with historical references both in the Tibetan tradition and in Traditional Chinese Medicine (TCM) in terms of its use as a general tonic and for the healing of wounds, ulcers, and as a local anti-inflammatory. Nowadays, it is one of the most used sources in the elaboration of omega 7 based food supplements. Omega 7 benefits that have been proven According to studies, consuming omega 7 improves the hydration of ‘mucous membranes’ (ocular, buccal, vaginal. Moreover, it promotes skin regeneration, improves insulin sensitivity, and supports an increase in HDL cholesterol levels in metabolic syndrome cases. For the health of the skin and mucous membranes, Other interesting studies on palmitoleic acid have focused on the health of the skin and mucous membranes, based on the fact that omega 7 is present in both body structures. It is known that sea buckthorn oil activates the physiological functions of the skin and reduces scars. If applied topically relieves skin burns (caused by sun exposure or radiation therapy), irritation, sores, and skin change. But this oil is beneficial even for people without skin disorders, since it improves hydration and elasticity of the skin, reduces wrinkles, and reduces inflammation. And its benefits for mucous membranes have also been proven. We speak of epithelial tissues specialized in covering the ducts and cavities exposed to the environment, including the digestive organs (oral cavity, pharynx, esophagus, stomach, small intestine, colon, and rectum), respiratory (nasal mucosa, trachea, and bronchi), urological (urethra, bladder, ureters), the female genitalia (part of the vulva and vagina) and the inside of the eye. These surfaces are very sensitive and if they suffer any alteration can cause health problems, as well as create “cracks” entry of potential pathogens that can lead to infections. For this reason, although generally it is not usually paid special attention to the health of the mucous membranes, omega 7 can be a great help in their care. According to studies, it could be useful in vaginal atrophy associated with menopause, which produces a thinning and dry vaginal mucosa. And the administration of sea buckthorn oil improves the dryness and integrity of the vaginal epithelium, so it could be a good alternative to conventional estrogen hormone treatment in women who cannot tolerate it correctly¹⁷.

Source of Omega 7 fatty acids: -

Many Omega-7 foods provide health benefits as well. Here are some of the best foods to find Omega 7 fatty acids in:

- Sea buckthorn
- Macadamia oil
- Dandelion oil
- Avocado oil
- Pomegranate oil
- Tuna
- Salmon
- Sardines
- Anchovies

Role of Omega 7 fatty acids in Health care

1] Hydration

Hydration is necessary for your body inside and outside. The intrinsic benefits of omega-7 fatty acids are to keep your overall body hydrated. It also helps to lubricate the mucous membranes, which helps with dry eyes as

well as vaginal dryness frequent in many postmenopausal women. Externally, we could notice a significant improvement to your skin and lips because Omega 7 will provide a natural barrier to keep moisture in the skin.

2] Gastrointestinal health

These fatty acids are beneficial for the GI tract and can help with excess acidity, ulcers, and indigestion. While taking an Omega 7 supplement on a daily basis, digestive discomforts including pain and burning in the stomach are frequently relieved. Just as lubricated mucous membranes can help ease the previously mentioned dryness issues, GIT issues are reduced or eliminated as a result of better lubrication. Omega 7 fatty acids are effective in treating chronic discomfort, which is frequently brought on by acidic diets or ulcers. Your energy levels rise and you feel better when your digestive system functions properly.

3] Youthful appearance

Omega 7 has numerous advantages for your skin and supports the collagen in your skin, which helps heal from various types of damage. Skin problems including acne and other problems caused by inflammation can also be eliminated by taking an omega-7 diet. In addition, healthy, hydrated skin helps prevent loss of skin elasticity so that skin is protected against wrinkles. Your hair will be shinier and stronger and healthier nails. If your skin is healthy, you feel younger than your age.

4] Healthy heart

Omega 7 is having amazing benefits for your heart. It can help lower your risk of heart disease and diabetes because it helps regulate blood sugar levels and cholesterol. Omega 7 can help reduce fat cell accumulation and keep artery walls strong and strong so that blood can flow easily. Omega 7 fatty acids also help raise good cholesterol and lower bad cholesterol and have been found to be instrumental in weight loss or control. All these factors improve the health of the cardiovascular system overall and help with so many other conditions or diseases.

By consuming omega-7 foods, you can:

- Reduce the risk of heart disease
- Reduce risk of blood clots
- Maintain blood pressure
- Stabilize blood sugars
- Lower bad cholesterol
- Protect against diabetes
- Boost the immune system
- Renew energy
- Rejuvenate skin and hair health

The majority of the advantages have been attributed by experts to Omega 7's palmitoleic acid, which is also its most significant acid.

DIFFERENCES BETWEEN THE OMEGA FATTY ACIDS

OMEGA	WHAT DOES IT DO	FOOD TO EAT
Omega -3	Control blood clotting, Build cellular membranes in the brain and joints, fat loss, muscle building benefits in athletes, reduce risk of cancer, heart diseases, and diabetes, and reduce inflammation.	Fatty fish (salmon, mackerel, cod, etc) Vegetable oil (soybean, walnuts, flaxseeds, etc) Green vegetables (kale, spinach, brussels sprouts, salad green, etc)
Omega -6	Regulates brain functioning, regulates growth, and development, Stimulates hair and skin growth, Regulates metabolism, maintains healthy bones and reproductive system, increases	Most vegetables oils, nuts, grains, fed and meats

	inflammation,	
Omega -7	Reduces inflammation, Reduces insulin resistance.	Its produced naturally by the body but can also be found in foods with palmitic acid like macadamia nuts and sea buckthorn.
Omega -9	Reduces inflammation, improves joint health and healing, and prevents various diseases.	Produce naturally by the body, but can also be found in olive oil and vegetable oil.

OMEGA-9 FATTY ACIDS

Omega-9 is one of the main mono-unsaturated fatty acids (MUFA) found in many plants and animals. These types of fatty acids are synthesized by the human body, but they are not enough to meet all the body's needs. Consequently, they are considered partially essential fatty acids. MUFA represents a healthier alternative to saturated animal fats and has several health benefits, including anti-inflammatory and anti-cancer characteristics. Omega-9 Fatty acids ($\omega-9$) have a double bond in the 9th position from the methyl end and are either monounsaturated or polyunsaturated. Unlike the omega -3 and -6 and Omega-9 FAs, are considered "non-essential" FAs¹⁸.

Role of Omega 9 fatty acids in Healthcare

1] Anti-inflammatory actions

A rich diet of oleic acid is beneficial for inflammatory illnesses. Activating numerous immunologically competent cell pathways modifies the immune system¹⁹. Yet, the literature has conflicting information about its biological usefulness in many cellular processes. Here is a few encouraging research that demonstrates the anti-inflammatory properties of Oleic acid in several organ systems.

2] Liver inflammation: -

When a disease-causing microbe or drug attacks liver cells, liver inflammation occurs. The term hepatitis refers to liver inflammation. Hepatitis is mainly caused by a viral infection, but it may also be caused by an autoimmune disorder. Alcohol, toxins, and some medications can also cause liver damage, which can lead to inflammation. Hepatitis may also be caused by hereditary disorders, as well as a chronic obstruction of bile flow. The type of hepatitis determines the severity, treatment, and outcome of liver inflammation. Extra virgin olive oil, rich in OA, can help prevent inflammation, mitochondrial dysfunction, insulin resistance, endoplasmic reticulum (ER) stress, and oxidative stress by activating various sign-signaling pathways in hepatic parenchymal cells¹⁹.

3] Eye inflammation: -

Anti-inflammatory effect of oleic acid against hyperlipidemia-induced retinal inflammation in male Wistar rats. Proinflammatory serum and retinal cytokines like IL-1-, TNF-, and MCP-1 were reduced by a high OA diet (17.5% diet high in olive oil) given for 90 days. Additionally, it reduced the expression of retinal BLT-1, EP-4, EP-1, and COX-2 as well as serum C reactive protein (CRP), pro-inflammatory eicosanoids (LTC4, LTB4, and PGE2), and PGE2 in comparison to control rats fed a 7.0% lard-rich diet. It has been demonstrated that OA has possible therapeutic benefits in enhancing both hydrophilic and lipophilic compound ocular drug delivery²⁰. Additionally, several studies have shown that lipid-based lubricants can aid in the relief of some dry eye symptoms²¹.

4] Skin inflammation: -

Oleic acid was shown to alleviate skin inflammation by altering neutrophils' role in immunity; however, binding to albumin diminishes its anti-inflammatory activity. A study investigated the effect of the incorporation of OA within nanostructured lipid carriers (OA-NLC) in improving anti-inflammatory actions. Topical application of OA-NLC as an ointment alleviated neutrophil infiltration and relieved skin inflammation severity. Whether such

disease improvement is correlated with increased OA levels inside the skin tissue should be determined to be more conclusive. Additionally, OA plays a crucial role in wound healing by inducing rapid wound closure which is essential to prevent superimposing infections and delayed healing²².

5] Lung inflammation: -

Pneumonitis is lung tissue inflammation. Lung inflammation may be acute or chronic and is caused by diseases such as asthma and bronchitis, environmental factors, and infections. Lung damage caused by OA is a commonly used model that closely resembles human disease. OA has been found to possess anti-inflammatory activities toward activated neutrophils. OA-based nanosystems mitigated acute respiratory distress syndrome in mice via the suppression of neutrophils²³.

6] Anti-cancer actions: -

OA has been shown in numerous reports to inhibit cellular proliferation in several tumor cell lines. OA inhibited HER2 overexpression, a well-known oncogene involved in the development, and metastasis of numerous human cancers. In carcinoma cells, OA also plays a significant role in the intracellular calcium signaling pathways related to apoptosis and growth induction. The mechanisms underlying the apoptotic event caused by OA are linked to the rise in intracellular caspase 3 activity and the development of ROS²⁴. OA downregulated cancer activity of human esophageal cells (HEC) through several mechanisms including suppressing cell proliferation, cellular migration, and adhesive properties as mediated via activating tumor suppressor genes (p27, p21, and p53). Although OA treatment of HEC did not influence the number of colonies, it inhibited the colony size remarkably²⁵.

SYNTHESIS PATHWAY FOR OMEGA (n)7 AND n-9 MONOUNSATURATED FATTY ACIDS

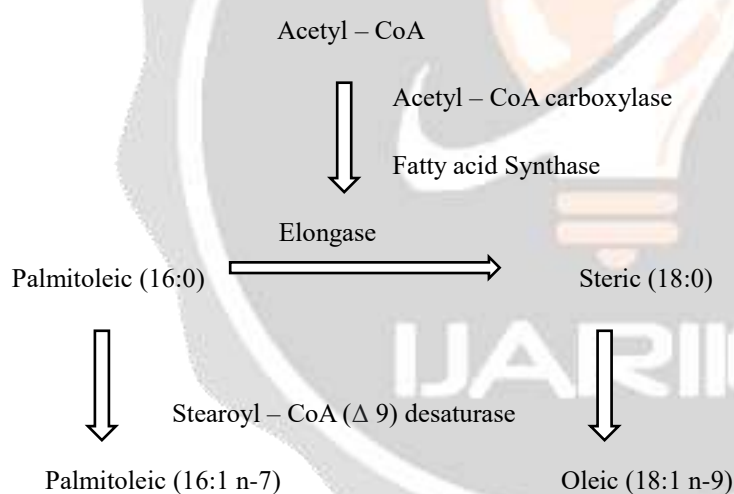


Fig: 2 (Synthesis pathway for omega (n)7 and n-9 monounsaturated fatty acids)

CONCLUSION: -

Omega fatty acids exhibit essentially countless pharmacological activities that make them a strong candidate to treat a wide range of pathological conditions. The observed omega -3 and -6 polyunsaturated fatty acids mediate neuroactive effects of peripheral nerve and spinal cord injury, cellular mechanism of polyunsaturated fatty acids includes reduced neuroinflammation, oxidative stress, enhanced neurotropic support, and activation of cell survival pathways. In recent years, a scientist has focused their attention on family members of omega-7 fatty acids, which has been shown to improve skin and mucous membrane health as well as insulin sensitivity and prevent cardiovascular diseases. The omega-9 fatty acids have been observed in many physiological and pathological conditions such as wound healing, Anti-inflammatory action in humans and animals such as eyes, lungs, and liver inflammations, insulin resistance, and anticancer action.

REFERENCES

1. Patterson E, Wall R, Fitzgerald GF, Ross RP, Stanton C. Health implications of high dietary omega-6 polyunsaturated Fatty acids. *J Nutr Metab.* 2012;2012:539426.
2. Adarme-vega T.C, Lim DKY, Timmins M, Vernen Felicitas, Schenk PM. Adarme-vega et al. microbial cell factories, 2012, 11:96.
3. Ward OP, Singh A: Omega-3/6 fatty acids: alternative sources of production. *Process Biochem* 2005, 40(12):3627–3652.
4. Von Schacky C, Harris WS: Cardiovascular benefits of omega-3 fatty acids. *Cardiovasc Res* 2007, 73(2):310–315.
5. Li Y, Qin JG, Moore RB, Ball AS: Perspectives of marine phytoplankton as a source of nutrition and bioenergy. In *Marine phytoplankton*. Edited by. New York: Nova Science Pub Inc; 2009, 14.
6. Hathaway D, Pandav K, Patel M, Riva-Moscoso A, Singh BM, Patel A, Min ZC, Singh-Makkar S, Sana MK, Sanchez-Dopazo R, Desir R, Fahem MMM, Manella S, Rodriguez I, Alvarez A, Abreu R. Omega 3 Fatty Acids and COVID-19: A Comprehensive Review. *Infect Chemother.* 2020 Dec;52(4):478-495.
7. Yashodhara BM, Umakanth S, Pappachan JM, Bhat SK, Kamath R, Choo BH. Omega-3 fatty acids: a comprehensive review of their role in health and disease. *Postgrad Med J.* 2009 Feb;85(1000):84-90.
8. Helland IB, Smith L, Saarem K, Saugstad OD, Drevon CA. Maternal supplementation with very long-chain n-3 fatty acids during pregnancy and lactation augments children's IQ at 4 years of age. *Pediatrics.* 2003 Jan;111(1):e39-44
9. Goldberg RJ, Katz J. A meta-analysis of the analgesic effects of omega-3 polyunsaturated fatty acid supplementation for inflammatory joint pain. *Pain* 2007;129:210–23.
10. Bang HO, Dyerberg J, Hjoorne N. The composition of food consumed by Greenland Eskimos. *Acta Med Scand.* 1976;200(1-2):69-73.
11. Goodnight SH Jr, Harris WS, Connor WE. The effects of dietary omega 3 fatty acids on platelet composition and function in man: a prospective, controlled study. *Blood* 1981;58:880–5.
12. Lee JH, O'Keefe JH, Lavie CJ, Marchioli R, Harris WS. Omega-3 fatty acids for cardioprotection. *Mayo Clin Proc.* 2008 Mar;83(3):324-332.
13. Safarinejad MR, Safarinejad S. The roles of omega-3 and omega-6 fatty acids in idiopathic male infertility. *Asian J Andrology.* 2012 Jul;14(4):514-515.
14. Jeppesen C, Schiller K, Schulze MB. Omega-3 and omega-6 fatty acids and type 2 diabetes. *Curr Diab Rep.* 2013;13(2):279-288.
15. Silva JR, Burger B, Kühl CMC, Candreva T, Dos Anjos MBP, Rodrigues HG. Wound Healing and Omega-6 Fatty Acids: From Inflammation to Repair. *Mediators Inflamm.* 2018;2018:2503950.
16. Nunes EA, Rafacho A. Implications of Palmitoleic Acid (Palmitoleate) On Glucose Homeostasis, Insulin Resistance and Diabetes. *Curr Drug Targets.* 2017;18(6):619-628.
17. Garcia V L. The Omega 7 as a Health Strategy for the Skin and Mucous Membranes. *EC Nutrition* 14.6 (2019): 484- 489.
18. De Lorgeril M (2007) Essential polyunsaturated fatty acids, inflammation, atherosclerosis, and cardiovascular diseases. *Subcell Biochem*, 2007;42:283–297.
19. Carrillo C, Cavia Mdel M, Alonso-Torre S Role of oleic acid in the immune system; mechanism of action; a review. *Nutr Hosp* 2012;27(4):978–990.
20. Gao XC, Qi HP, Bai JH, Huang L, Cui H. Effects of oleic acid on the corneal permeability of compounds and evaluation of its ocular irritation of rabbit eyes. *Curr Eye Res.* 2014;39(12):1161-8.
21. Lee SY, Tong L. Lipid-containing lubricants for dry eye: a systematic review. *Optom Vis Sci.* 2012;89(11):1654-61.
22. Rodrigues HG, Vinolo MA, Magdalon J, Vitzel K, Nachbar RT, Pessoa AF, dos Santos MF, Hatanaka E, Calder PC, Curi R. Oral administration of oleic or linoleic acid accelerates the inflammatory phase of wound healing. *J Invest Dermatol*, 2012;132(1):208–15
23. Gonçalves-de-Albuquerque CF, Silva AR, Burth P, Castro-Faria MV, Castro-Faria-Neto HC (2015) Acute respiratory distress syndrome: role of oleic acid-triggered lung injury and inflammation. *Mediator of inflammation.* 2015:260465.
24. Farag MA, Gad MZ. Omega-9 fatty acids: potential roles in inflammation and cancer management. *J Genet Eng Biotechnology.* 2022;16;20(1):48.
25. Carrillo C, Cavia Mdel M, Alonso-Torre SR. Antitumor effect of oleic acid; mechanisms of action: a review. *Nutr Hosp.* 2012;27(6):1860-5.